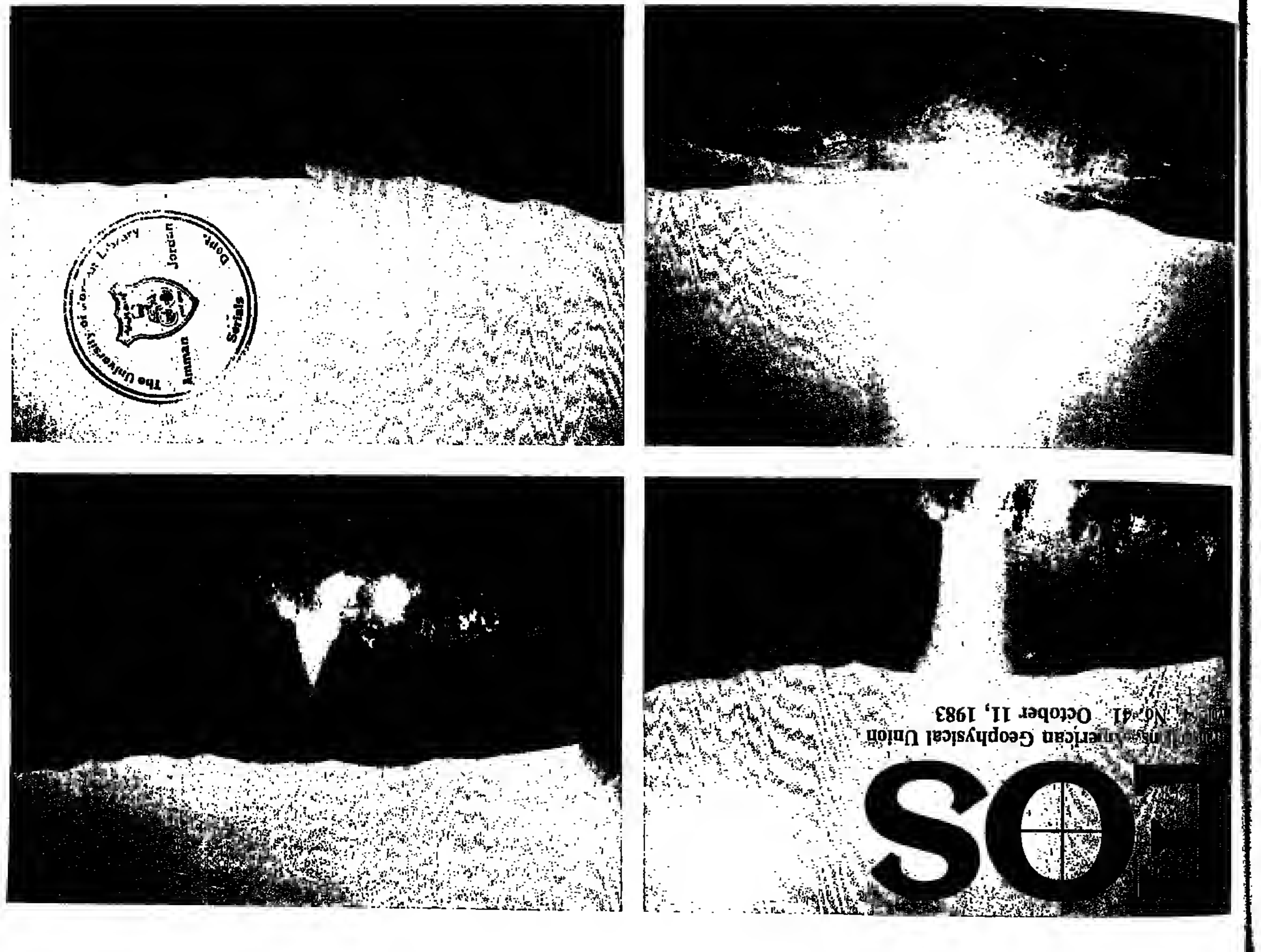

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Seismology

FOCAL MECHANISMS AND DEPTHS OF EARTHQUAKES IN CENTRAL PAKISTAN: A TECTONIC INTERPRETATION

Solar Physics, Astrophysics, and Astronomy

Volcanology

The Geodetic Activities of the Department of Defense Under IGY Programs

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The International Geophysical Year (IGY) programs have special significance to geodesists. The IGY witnessed the launching of the first manmade earth satellite and the beginning of the era of global geodesy. It is no wonder that the U.S. Department of Defense (DoD) with its global geodesy requirements developed an early interest in satellite geodesy. Specifically, this led to the use of early satellites of opportunity (and subsequently of dedicated satellites) for worldwide navigation, geodetic positioning, and gravimetric investigations. In conjunction with other civilian satellite programs under the IGY, DoD played a major role in the achievement of geodetic goals perhaps far beyond that which was envisioned originally. An early satellite program was the project ANNA with the basic concept originating from the DoD. ANNA, a truly cooperative effort, involved the three defense services, NASA, and other civilian agencies. Other examples under satellite programs included many camera and electronic measuring techniques, especially the U.S. Navy's Doppler system, the Army's SECOR, and the pioneering development of laser illuminating and ranging experiments by the Air Force. On this occasion marking the 25th anniversary of the IGY, this article recalls some of the DoD activities of the initial years that fulfilled the geodetic objectives of the IGY and highlights those activities that grew out of the IGY to become today's technology.

1. Introduction

Any discussion of the U.S. Department of Defense participation in the International Geophysical Year (IGY) must begin by recalling the state of geodesy in 1957. Geodetic observations were generally limited to "line of sight." Coordinates of places, say, in North America, were known relative to those in Eurasia to an accuracy of perhaps a couple hundred meters or so. The earth ellipsoid devised by Hayford in 1910 had been named the "International" in Madrid in 1924 and had been used to adjust the European Datum in 1950. The Potsdam determination of absolute gravity and the International gravity formula represented the state of the art in gravimetry.

In the matter of education, prior to 1955, there were no Ph.D.-granting programs in geodesy in the entire western hemisphere. So, it is not surprising that the U.S. Department of Defense (DoD), with its global requirements for geodetic and geophysical information, assumed a leading role in the programs of the IGY. During the ensuing 25 years, DoD has dramatically demonstrated its serious commitment to the enhancement of geodetic and geophysical knowledge on an international scale. There is little doubt that the present day state of the art in geodetic science owes its existence in a large part to the efforts of the U.S. DoD. The long list of technological developments that received their impetus and funding from DoD includes such items as rocket flare triangulation (when we were attempting, in the early days, to tie distant land masses together), the application of lunar occultations and solar eclipses for geodesy, airborne gravimetry, the use of satellites for surveying, the application of inertial technology to surveying, and many others.

The International Geophysical Year (IGY) programs, a truly remarkable scientific enterprise and a cooperative effort shared by over 50 nations, formally began on July 1, 1957. However, some earlier operations such as the landing of U.S. Naval and Air Force aircrafts in McMurdo Sound and the opening of the Amundsen-Scott South Pole Station during October 1956 well in advance of the full-scale IGY were clear indications of the faith, interest, and commitment the DoD in general had in the IGY.

The launching of the first manmade earth satellite in 1957 announced the explosive arrival of the "real" space age in geodesy, and DoD developed an early interest in the resulting infant science of satellite geodesy. Specifically, this led to the use of early satellites of opportunity (and subsequently of dedicated satellites such as ANNA, PAGEOS, GEOS, and the Navy Navigation Satellite System) for worldwide navigation, geodetic positioning, and gravimetric investigations. The activities also resulted in the establishment of DoD's pioneering World Geodetic System (WGS) in 1960, defining a global geodetic network, geoid, and the earth's gravity field model.

In conjunction with other civilian satellite programs under the IGY, DoD played a major role in the achievement of geodetic goals, perhaps far beyond that which was envisioned originally. An early start was the project ANNA. Other earlier satellite programs from DoD also included many camera and electronic measuring techniques, especially the U.S. Navy's MINITRACK and Doppler system (or the Navy Navigation Satellite System, NNSS), the Army's SECOR (or Sequential Collation of Ranges), and the Air Force's PC-1000 camera system. From a conservative objective of a 200-m navigational accuracy, the Doppler system today has become an extremely practical geodetic tool that routinely provides geodetic network control of 1 m or better accuracy over entire continents. And now, the Air Force's latest 18 satellite Global Positioning System (GPS) promises worldwide geodetic accuracies of subdecimeter level.

As part of the overall objective of the IGY gravity program, DoD has always played a major role in the extension and completion of a worldwide network of gravity measurements. From the initial measurement of pendulum bases for control purposes, the DoD effort has been to conduct research and develop better instruments and to aid materially in eliminating the serious gaps in the international network of gravity measurements.

2. IGY Activities

More than 5 years of extensive planning and preparation were devoted to the development of the 1957 IGY programs which were to become a concentration of intense effort to diminish great gaps in our knowledge of the planet earth and its surrounding regions. It should be remembered that the synoptic objectives of these programs also included simultaneous observations in most of the disciplines including polar, weather, solar, and ionospheric programs throughout the world. To achieve simultaneous observations, regular schedules were arranged through international cooperation. To achieve the desired intensification in the observational programs, Regular World Days (RWD) and Special World Intervals (SWI) programs were also designated. The driving motivation was that the resulting concentration of efforts under these programs would be useful in the interpretation of overall results.

If DoD was not in the forefront in every program, it was there contributing one way or the other. Having had direct or indirect experience with these activities, we want to share with you the role that DoD played in the IGY programs.

3. Satellite Programs

The geodetic satellite programs and satellite geodesy grew out of the upper-air rocket research activities, both during IGY and previous years. The Air Force Cambridge Research Center, now the Air Force Geophysics Laboratory (AFGL), Army Ordnance, Naval Research Laboratory (NRL), Navy Bureau of Ordnance, Holloman Air Force Base, Naval Air Missile Test Center, and various U.S. Navy ships (e.g., *The Compass Island*) are some of the DoD components that were in the forefront. Research rockets provided extremely valuable information regarding pressure, temperature, density, and chemical and ionic composition of the atmosphere. They also yielded information about winds, airflow, ionospheric charge density and refraction, solar radiation, and the earth's magnetic field, in addition to being the forerunners of the satellite flights.

The IGY witnessed the launching of the first manmade earth satellite and the beginning of the era of global geodesy. The use of satellites as additional tools in geodetic research and operations was immediately adopted universally, with the official endorsement for such a role coming from the International Union of Geodesy and Geophysics (IUGG) in 1960.

Our interest within DoD started with the use of early satellites of opportunity and then quickly turned into programs for the development of dedicated geodetic satellites such as ANNA.

3.1 *Project ANNA*

With the basic concept originating from DoD in 1958, ANNA (Army, Navy, National Aeronautics and Space Administration, Air Force) was a truly cooperative effort and soon became the test bed for satellite geodetic methods. The extensive research and dedicated efforts of the three defense services, NASA, the Applied Physics Laboratory (APL), and other civilian agencies resulted in the launching of ANNA 1A on May 10, 1962. However, the attempt to place the first "true" geodetic satellite into orbit failed when the second-stage rocket engine did not ignite. Thus, ANNA 1B, launched on October 31, 1962, has the distinction of being the first geodetic satellite.

The basic mission for ANNA 1B was to improve existing geodetic control and to test and compare the performance of other forthcoming systems such as a transponder from the Army's SECOR, flashing lights for the Air Force's PC-1000 camera, NASA's MINITRACK optical tracking system (MOTS) camera, and the National Geodetic Survey's (then U.S. Coast and Geodetic Survey) BC-4 camera and a Doppler beacon for the APL and Naval Weapons Laboratory (NWL) tracking systems.

3.2 *The MINITRACK Systems*

Prior to the launching of U.S. satellites under the IGY programs, NRL had already established MINITRACK stations. The first satellite, Explorer 1, launched in 1958, was a joint venture between the Army Ballistic Missile Agency (BMA) and the Jet Propulsion Laboratory (JPL). The second satellite, Vanguard 1, was sponsored by NRL, and the third was again a joint effort of BMA and JPL. These two satellites followed within the next 2 months the launching of Explorer 1.

Even in those early years, the Vanguard satellites were associated with an orbital lifetime of at least 200 years. It was also expected that these satellites with their spherical shape and stable orbits would prove very useful in geodetic and air density studies. Of course, not all those expectations became realities, but the Vanguard IGY satellite program definitely succeeded in laying down a sound foundation for the other projects to follow.

NRL's MINITRACK system became so dense during the early years of this program that it created an electronic "fence" along the 75th west meridian, which every satellite had to cross.

Under the Vanguard 1 satellite program, the comparatively inexpensive MINITRACK Mark II (developed from Mark I) ultimately became operational and was later routinely used by NRL for tracking and obtaining useful data for orbit computations.

3.3 *PC-1000 Geodetic Camera System*

The development for this camera system began near the end of IGY activities at AFCRL. This Air Force system had a lens with a focal length of about 1000 mm, and hence the name. Its chopping shutter allowed observations of the flashing lights from ANNA 1B (section 3.1) or subsequent geodetic active satellites like GEOS 1. This shutter performed equally well with the passive satellites such as ECHO or PAGEOS, which followed later. The PC-1000's were complemented and augmented by the BC-4 camera system employed by the National Geodetic Survey (then Coast and Geodetic Survey).

These cameras were utilized for long range space triangulation for global/continental geodetic control networks. One such network, extending from Curacao to Asuncion, which can be commendably mentioned here, provided much needed control over South America.

3.4 *Navy Navigation Satellite System*

The concept for the Navy Navigation Satellite System (NNSS) or the Doppler system became a reality in 1958. By 1959 the experimental satellite TRANSIT 1A and five tracking stations had been designed and constructed.

Although the TRANSIT 1A satellite failed to achieve orbit, a full development program for the system officially began in 1959. The program's success started with the next satellite TRANSIT 1B (launch date of April 13, 1960) and continued with followups like transit 2A, 3B, 4A, 4B, 5A, etc. The Doppler system witnessed another threshold with the generation of new drag free satellites, the first of which was NOVA 1 (launch date of July 1981). The accuracy improvement has been phenomenal from the modest goals of about 200 m of the earlier years. The Doppler system of today has become one of the most efficient, accurate, and practical geodetic tools for routinely providing geodetic control of 1 m or better accuracy, both for individual stations and/or as part of n station network that uses ground equipment such as the geoceiver.

3.5 *Geodetic SECOR System*

The concept for this system also originated near the end of the IGY years and the first transponder went into space with ANNA 1B (section 3.1). The system was based on the solution of a ground-based four-station tracking pyramid with the satellite transponder as the vertex in space. Over the duration of the SECOR system, an equatorial belt of tracking stations was established. Many of the stations were collocated with BC-4 stations, thus providing additional scale to the PAGEOS network.

After the first SECOR transponder was carried in ANNA 1B, the Army launched additional high and low altitude satellites for the SECOR system between 1964 and 1970. The system was then phased out owing to the high cost associated with the operational

3.6 *Other Systems*

The first Baker-Nunn camera of the Smithsonian Astrophysical Observatory was installed at Organ Pass, New Mexico, on November 15, 1957. Shortly thereafter the U.S. IGY program established 12 worldwide Baker-Nunn tracking stations. In this extensive optical tracking program, DoD was there to provide valuable logistic and operational support.

The 1959 Iota satellite was placed in orbit by the Army Ballistic Missile Agency as a contribution to the 1959 extension of the IGY, the International Geophysical Cooperation 1959. It turned out to be the last satellite of the IGY programs. The vital initial tracking of 1959 Iota was accomplished by U.S. Army Microlock stations in the United States and Bermuda.

Another satellite program worth mentioning was NRL's Solar Radiation Measuring Satellite or "Sunray." This satellite was carried in a "piggyback" mode with the TRANSIT IIA vehicle of the Doppler system. Although the project was of primary interest to geophysicists, the ionospheric research also contributed information of value for geodesists about accurate orbit computations.

4. Satellite Geodesy

If the concepts and the groundwork for the era of satellite geodesy had been laid before the IGY years through research rockets, the results of geodetic importance came after the launching of the first manmade earth satellite. It was the team of DoD scientists headed by John O'Keefe in 1958 that determined the first definitive result of 1/298.3 for the earth's flattening by using the Vanguard satellite.

From the investigations regarding variations in the orbit of Vanguard 1, DoD was again in the forefront to suggest a modification to the traditional concept of the earth as a rotational ellipsoid. The calculations established the existence of a third zonal harmonic, which in turn required a triaxial ellipsoid with an elliptic geodetic equator and the earth's shape somewhat resembling a pear.

Even if the geodetic activities under the IGY did not provide all the solutions, the research originating under IGY programs became the foundation of achievements that followed in later years. A striking example here would be the NNSS or the Doppler effort. It would be impossible, in the allocated time and space, to describe adequately the achievements in this area. However, once the navigational requirements were satisfied, TRANET observations of the Doppler shift were utilized over the years for continuous improvement of our knowledge of the geo-

Article (cont. on p. 596)

Owen W. Williams received his B.A., with honors, from Kalamazoo College, Michigan, in 1948 and completed postgraduate studies at George Washington University, Washington, D.C., in 1951. He has served as a visiting lecturer in Earth Sciences in Europe and Scandinavia, and in 1967 he was guest lecturer on "Cosmic Geodesy" at the request of the Soviet Academy of Sciences. He retired from the U.S. Government in August 1982, having served in numerous progressively responsible positions culminating as Deputy Director, Management and Technology, for the Defense Mapping Agency (DMA), the highest civilian position in DMA. He has authored over 45 scientific and technical papers, which have been published in national and international journals in the fields of geodesy, gravity, and geophysics.

Kenneth I. Daugherty received a B.S. in mathematics, geography, and geology from Morehead State College in 1957; an M.S. in geodesy from Ohio State University in 1964; Filosofie Licentiate in 1972; and a Ph.D. in geodesy in 1974 from Uppsala University. He joined the Air Force Aeronautical Chart and Information Center in 1957 and held a variety of line and staff positions there. During this time he worked on pioneer efforts to establish the role of geodetic and geophysical support for ballistic missiles and was a member of USAF Science Advisory Board ad hoc group on geodesy and geophysics. From 1967 to 1974 he was associate professor of geodesy and assistant director of the Hawaii Institute of Geophysics, conducting research in physical geodesy, satellite geodesy, and marine geodesy and geophysics. During 1971–1972, he was a student and a visiting scientist at Geodetic Institute, Uppsala, Sweden. In 1974, he joined the Defense Mapping Agency as chief, Department of Geodesy, DMA Topographic Center. From 1975 to 1978 he was on Headquarters DMA staff. Since 1979 he has been the technical director of the DMA Hydrographic/Topographic Center. Kenneth I. Daugherty is assistant-secretary of the International Association of Geodesy. He is recipient of the USAF Meritorious Civilian Service Award and the DMA Distinguished Civilian Service Award.

The VGP News

"Mind and Mallet and Crucible"
[Originally appeared in *The Geochemical News*, 9, 5, 1958.]

Editor: Bruce Doe, 11721 Dry River Court, Reston, VA 22091 (telephone 703-860-3470, after 5:30 p.m.).

News & Announcements

Travel Grants to IGC

The U.S. National Committee for Geochemistry is seeking funding for its Travel Grant Program to the 27th International Geological Congress to be held in Moscow August 4–14, 1984. In cooperation with other organizations, the committee seeks to ensure appropriate U.S. participation by providing 10–20 travel grants to enable geochemists residing in the United States to attend. Travel grants are to be awarded based in part on a screening subcommittee's ranking of abstracts submitted for presentation at the congress. Special consideration will be given to younger geochemists and those judged to benefit most by participating in this important international congress.

To apply, send six fastened-together sets of completed applications, including completed form and abstract (900–1200 words) of paper to be presented, to W. L. Petrie, USNC/Geochemistry, NAS-NRC, 2101 Constitution Ave., Washington, DC 20418 by January 31, 1984. (Forms available from Petrie.) Travel grantees must use U.S. flag carriers wherever possible and must file a meaningful trip report before October 14, 1984.

Depending on the availability of funds, travel grant awards may be made by May 1, 1984. However, cancellations and other factors may delay a few grant awards to as late as August 1, 1984, or possibly after the congress.

Research Grants Announced

Krueger Enterprises, Inc., has announced the winners of its 1983 Geochron Research Competition. Two awards were granted to support research proposals in each of the following areas: K-Ar dating, C-14 analyses, and Stable Isotope Ratio Analyses (SIRA).

Winners in the K-Ar dating area, their school, and their research topics are James J. Hardy, Jr., Northern Arizona Univ., The use of the K-Ar method to date a major thrust event in west-central Arizona; and Christopher S. Lynnes, Univ. of Michigan, Correlation with age of magnetization in Cambro-Ordovician intrusives from Colorado.

In C-14 analyses: Kee Hyun Kim, Florida State Univ., Cross-check of uranium-series disequilibrium ages by radiocarbon dating: Marine phosphate nodules and their associated sediments; and Charles K. Paull, Scripps Institution of Oceanography, The origin of stratigraphic offsets in deep-sea cores.

In SIRA: Teofilo A. Abrajano, Jr., Washington Univ., Origin and significance of sulfide phases in selected mantle assemblages; and Virginia B. Sisson, Princeton Univ., Oxygen isotope work on the Ponder pluton and associated rocks.

According to Krueger, the awards, which amount to about $1500 worth of analytical services for use in the research, are to be made again in 1984 in the same three areas as well as in Rb-Sr or U-Pb analyses. More information may be obtained from Krueger Enterprises, Inc., 24 Blackstone St., Cambridge, MA 02139 (telephone 617-876-3691).

Meetings

Cosmogenic Radionuclides

Cosmic rays interact with the earth's atmosphere and surface to produce the "cosmogenic" nuclides. In many instances the radioactive ones are readily distinguished from the anthropogenic and meteoritic backgrounds. Measurements of these cosmogenic radionuclides (RCN) can contribute to the solution of a variety of geophysical problems [*Lal and Peters*, 1967]. Recent progress in this area was discussed at a symposium entitled Application of Cosmic-Ray-Produced Nuclides in Geophysics held May 30, 1983, at the AGU Spring Meeting in Baltimore [see *Eos*, May 3, 1983, pp. 282–284, for the abstracts]. We summarize here the symposium presentations.

The RCN accumulate differently in different terrestrial reservoirs. Table 1 shows some estimated global production rates and abundance levels for selected samples. In relatively simple collectors such as ice, the measurements may shed light on variations in production rates. In other collectors such as manganese nodules the observations may tell more about the object than about cosmic rays. Accordingly, we divide the following text into two sections. The first summarizes symposium contributions that emphasized cosmic ray histories and the second those that focused on the sample. Where the distinction blurs, the two sections overlap.

Cosmic Ray Variations

The total flux of solar and galactic cosmic ray particles determines the production rates of the RCN. J. R. Jokipii reviewed the types of temporal variability exhibited by the cosmic-ray flux. He noted the absence of large (>3-fold), long-term (10^5–10^8-years) variations that might be associated with galactic processes. Changes in solar activity are known to induce shorter-term variations. Of special interest here are (1) the 11-year solar cycle which normally gives rise to 25% changes in the cosmic ray flux and (2) a "cycle" lasting perhaps 200–400 years during which the flux may increase by a factor of 2 or 3 in response to solar modulation. Superimposed on the above is a cycle of about 10^4 years attributed to changes in the geomagnetic field [*Bucha*, 1967]. Direct observation of the sun has established the 11-year solar cycle and shorter term variations, namely burbling and gusting of the solar wind, Forbush decreases, and solar flares. Measurements of the RCN may supplement these measurements. They take on primary importance as we go further back in time.

TABLE 1. Cosmogenic Radionuclides in Selected Samples

Isotope	$t_{1/2}$, years	Production rate, atom $cm^{-2} s^{-1}$	Sample	Concentration, atom g^{-1}
^{39}Ar	2.7×10^2	$\sim 5 \times 10^{-7}$	Seawater	6
^{14}C	5.7×10^3	1.57*	Corals	7×10^9
^{36}Cl	3.0×10^5	1.1×10^{-3}	Groundwater	10^4
			Ice	4×10^3
^{26}Al	7.2×10^5	1.1×10^{-4}**	Tektites	2×10^5
^{10}Be	1.6×10^6	2.1×10^{-2}**	Rain	1.6×10^4
			Soils	10^7 – 10^9
			Lavas	5×10^6
			Phosphorites	10^9
			Mn nodules	5×10^9
			Petroleum	5×10^5

*Stuiver [1980].
**Reyss et al. [1981].

^{14}C in Corals

E. Druffel summarized some studies of ^{14}C, especially in corals. The 11-year solar cycle leads to calculated variations in the $^{14}C/^{12}C$ ratio too small to detect with available methods. Variations in $^{14}C/^{12}C$ ratios with a period of 200–400 years have been documented in several laboratories. Druffel has shown that corals that grew during the "little ice age" have elevated ^{14}C contents.

There are three questions now under study. (1) What is the relationship between climate and solar activity as recorded by RCN's? Present evidence is contradictory. (2) To what extent do oceanic circulation patterns influence the $^{14}C/^{12}C$ ratio of the atmosphere? Evidence from corals suggests that the effect is small. (3) Has ^{14}C production and its exchange rate between air and sea changed much over the last 60,000 years? At present, unknown factors cause ^{14}C ages to be 10% younger than U-series ages of Pleistocene samples. The difference could reflect either an increased ^{14}C production rate or a lower partial pressure of CO_2 in the atmosphere.

RCN in Ice

K. Nishiizumi determinations of longer-lived cosmogenic radionuclides in ice. Unlike soils or sediments, ice cores provide samples minimally diluted by stable isotopes that may interfere with measurements. In favorable cases ice cores give sharp temporal resolution, too. On the other hand, the RCN deposition rates can vary in response to atmospheric processes that may be only poorly understood. One way to test the fidelity of an isotopic record in ice is to compare it to one inferred from ^{14}C or ^{18}O studies.

Measurements of both ^{14}C and ^{10}Be in the Dye 3 ice core correlate well with sunspot activity subsequent to 1950. The ^{10}Be contents vary by a factor of two. Carbon-14 contents change less because the isotope's longer atmospheric residence time damps oscillations due to production rate variations. For the period prior to 1950 agreement between the ^{14}C and ^{10}Be sunspot records deteriorates for unknown reasons. Raisbeck et al. (1981) analyzed ^{10}Be in the Dome C ice core and found that samples deposited during the Maunder minimum had elevated ^{10}Be contents as expected. *Raisbeck et al.* [1981] and Oeschger and coworkers have reported increased ^{10}Be concentration during the last ice age. The ^{10}Be profiles correlate well with ^{18}O results. It is not known whether the enhanced ^{10}Be deposition reflects lower precipitation rates, changes in atmospheric circulation patterns or a higher production rate.

Finally, Nishiizumi summarized recent progress in the $^{10}Be/^{36}Cl$ dating of ice samples. Relative ages for two samples A and B can be calculated by assuming a constant $^{10}Be/^{36}Cl$ ratio in precipitation and the absence of radionuclide transport in ice. With the adoption of a modern $^{10}Be/^{36}Cl$ atom-atom ratio of 8, Nishiizumi concludes that near-surface ice from the Allan Hills region of Antarctica has an age of about 5×10^5 years.

^{10}Be in Lake Sediments

M. Wahlen reported the ^{10}Be contents of varved sediments from two New York State lakes with minimal bioturbation. The purpose of the study was to search for long- and short-term variations in the rates of production. The ^{10}Be fluxes calculated for Green Lake are divided into three periods: a baseline period with low deposition rates (0.016 atom $cm^{-2} s^{-1}$), a period of enhanced rates, during the Spörer and Maunder minima (up to 0.1 atom $cm^{-2} s^{-1}$), and the last 200 years or so during which ^{10}Be fluxes have steadily climbed toward a value near 0.5 atom $cm^{-2} s^{-1}$. The observations for the second period match in size but not in temporal detail similar results from ^{14}C. The recent increase in ^{10}Be deposition is attributed to increased soil erosion.

Sample Oriented Studies

^{10}Be in Rainfall

Deposition rates for the longer lived RCN are not yet well known. *O'Brien* [1979] calculated a global average production rate of 0.025 atom $cm^{-2} s^{-1}$ for ^{10}Be, while *Reyss et al.* [1981] estimated 0.021.

G. J. Stensland and M. C. Monaghan independently presented the results of several determinations of ^{10}Be in rainwater. The authors designed the experiments to learn more about the factors influencing ^{10}Be deposition. Stensland's group deployed traps open only when rain fell. At one site (Bondsville, Ill.) the average monthly fall-out rate ranged from about 1×10^4 to 2×10^4 atom ^{10}Be g^{-1} H_2O. Values were highest from May to August and lowest from October through March. The variations parallel those observed for ^7Be. Stensland noted that the Ca contents of the rainwater samples indicate contamination by fine soil particles. Raindrops or wind presumably lifted these particles into the air where they were entrained by raindrops on their way to the collectors. The concentration of ^{10}Be in the soil particles was not measured directly. Stensland estimates the contribution from this source may be as high as $\sim 1 \times 10^4$ atom ^{10}Be g^{-1} H_2O. This work demonstrates the need for care in the collection of samples.

Monaghan attempted to estimate the annual global production of ^{10}Be from measurements of ^{10}Be and ^{90}Sr in rainwater. Each sample consisted of a year's precipitation collected at one of eight sites in the United States. Dust may have contaminated some samples. The observed, latitude-dependent fluxes of ^{10}Be were normalized to global ones with the aid of the ^{90}Sr measurements and the known global deposition rate of ^{90}Sr. With various assumptions and a theoretical correction for tropospheric production Monaghan obtains a global production rate of about 0.018 at ^{10}Be/atom cm^2. From a comparison of the different sites, Monaghan concludes that the ^{10}Be flux as measured by precipitation at a particular location may not reliably reflect the ^{10}Be production rate.

^{39}Ar in Seawater

R. D. Willis presented the first profile of ^{39}Ar in seawater. The ^{39}Ar half-life (269 years) makes this isotope important for treatments of oceanic circulation. The time scale for ventilation of the ocean is now estimated mainly from determinations of the less sensitive ^{14}C. The samples discussed by Willis were collected at depths between 0 and 600 m in the north Pacific (GEOSECS I). Each of the five samples weighed about 2 tonnes (!), was counted for 2 months, and contained on the order of only 6 atom ^{39}Ar g^{-1} H_2O. The ^{39}Ar datum reported for 600 m differs significantly from the prediction of a ^{14}C box diffusion model. Three times lower than the calculated value, the observation suggests a removal rate of ^{39}Ar some 8 times faster than expected. Samples from depths of 4000 m remain to be counted.

Sources of Atmospheric Methane

S. Hameed estimated from the carbon isotopic ratios measured in atmospheric methane the fraction of methane derived from (1) the incomplete combustion of fossil fuels, (2) the partial burning of biomass, and (3) bacterial sources. Biomass burning may be more important than previously realized.

^{10}Be in Lavas

L. Brown discussed progress in studying ^{10}Be in volcanic rocks. The primary purpose of this ongoing work is to demonstrate that island-arc lavas contain measurable traces of pelagic sediments subducted from the sea floor. Semiquantitative estimates of the fraction of sediment-derived material present in a sample may then be possible. ^{10}Be acts as a good tracer for sedimentary matter for the following reason: Ocean sediments may contain up to 10^{10} atom ^{10}Be g^{-1} while igneous rock more than a few million years old should have virtually none. In the last year Brown and his colleagues have doubled the number of analyses of volcanic rocks, bringing the total to about 40. The experimenters took pains to try to minimize contamination from soil and rain. They divide their results into three groups. Twenty of 21 samples from the Aleutians and Central America contain between 2×10^6 and 5×10^6 atom ^{10}Be g^{-1}. In contrast, 10 non-island arc lavas and flood basalts have less than 1×10^5 atom ^{10}Be g^{-1}. Island arc samples from the Andes and the Far East seem to constitute an intermediate group: Most have low ^{10}Be contents but a few are similar to the Central American lavas. Brown prefers to defer comparisons of ^{10}Be with other elements until the ^{10}Be systematics are more firmly established. For the present he concludes that island-arc lavas do indeed contain ^{10}Be that once resided in pelagic ooze.

^{10}Be in Phosphorites, Mn Nodules, and Petroleum

C. Tuniz reported measurements of ^{10}Be in marine phosphorites. The aim of the study was to learn more about the timing of phosphorite formation. W. C. Burnett and H. H. Veeh have argued in several publications that U-Th disequilibrium dating supports a recent ($<3 \times 10^5$ years) origin for certain phosphorites collected off the coasts of Chile and Peru. Others have questioned this conclusion. Tuniz and coworkers showed that (1) phosphorites contain about 2×10^6 atom ^{10}Be g^{-1}, about twice as much as nearby sediments and (2) laminated phosphorites with ^{234}U-^{230}Th top-to-bottom age differences of a few thousand years have no ^{10}Be variability within experimental error as would be expected if the ^{234}U-^{230}Th ages were valid. Two kinds of blanks were discussed. Five million-year-old phosphorites from Bone Valley, Fla., have low ^{10}Be contents, consistent with radioactive decay, leaching, or a low initial complement of ^{10}Be. It remains to be seen whether very old submarine samples contain ^{10}Be from water-borne infiltration. A negative finding would strengthen the case for recent phosphorite origin.

Several groups have exploited accelerator mass spectrometry for the measurement of ^{10}Be and other cosmogenic radionuclides in manganese nodules and crusts. The results may be used to calculate growth rates; they may also give information about the conditions under which deposition occurred. A. Mangini and coworkers studied a manganese crust some 20–40 cm thick dredged from a depth of 4830 m in the central Pacific. They measured the ^{10}Be and metal contents of 18 samples. A plot of ^{10}Be by depth suggests a two-stage accumulation history: an early one lasting from 11 to 6 m.y. B.P. with a deposition rate of 4.8 mm/MY and a late one with a slower deposition rate of 2.7 mm/m.y. The shift at 6 m.y. B.P. may coincide with a discontinuity in the $\delta^{13}C$ record noted by others. With the aid of the growth rates, Mangini calculated dates for several petrographic and chemical changes observed in the crust. Many of these events apparently coincide with changes in paleoceanographic circulation inferred independently from the study of deep-sea sediments. Mangini concludes that the compact Mn nodules and crusts can provide paleoceanographic histories.

Motivated by the lack of reliable isotopic techniques for the age-determination of petroleum, F. Yiou and coworkers have begun a survey of ^{10}Be in various petroleum reservoirs. Oils older than 25 m.y. contain no detectable ^{10}Be; crude oils thought to be 2–5 m.y. old have detectable quantities of ^{10}Be, 4–9 × 10^4 atom g^{-1}; a modern, hydrocarbon-rich sediment contains 4×10^7 atom ^{10}Be g^{-1}, some of which may attach to the clastic component. The authors note that many factors may influence the ^{10}Be contents of crude oils, among them initial deposition conditions, exchange with water, sediments, reservoir rocks and kerogen, and migration history.

^{10}Be in Soils

M. Pavich and J. Klein both reported on ^{10}Be measurements in soils. The multiple origins of soil particles pose a difficult problem for isotopic dating of samples more than 10^5 years old. It has been suggested that with suitable modeling, ^{10}Be measurements may provide useful information about soil chronology. Pavich measured the ^{10}Be contents in soil columns from Merced River, Calif., terraces ranging in age from 0.04 to 3 m.y. As expected, total ^{10}Be inventories increase with column age and thickness. For the oldest columns, however, the standing crop of ^{10}Be falls short of the amount anticipated based on current estimates of the deposition rate and the assumption of complete retention. From the shortfall the authors estimate a ^{10}Be residence time of 6×10^5 years. *Monaghan et al.* [1983] obtain a lower value of about 10^4 years from an analogous study of other soil columns. Whether the discrepancy arises from sampling artifacts or site-specific differences is not resolved. Pavich notes a correlation between clay and ^{10}Be contents in the soils.

Klein and coworkers have been studying erosion in various watershed regions by applying mass balance to ^{10}Be. They measure the ^{10}Be contents of sediments from rivers or on continental margins, multiply by the sediment flux, and compare the result with the fall-out rate of ^{10}Be over the watershed. In a few cases such as the Amazon and the Susquehanna rivers, ^{10}Be inflow and outflow match to within a factor of 2. In many others such as the Mississippi and Yangtze rivers, ^{10}Be loss may exceed accretion by as much as a factor of 10. No "primordial" watershed has been found to give a steady-state for ^{10}Be. Thus, increased erosion due to agriculture may account for part but need not explain all of the net loss. Klein notes that, with a few exceptions, areas with the highest erosion rates produced sediments with the highest ^{10}Be contents. The authors conclude that erosion tends preferentially to carry away particles rich in ^{10}Be.

^{36}Cl in Groundwater

The relative inertness of aqueous Cl^- renders it especially suitable as a hydrologic tracer. Groundwater contains $^{36}Cl^-$ derived from three main sources: cosmic ray bombardment of the air and of rocks, activation of rocks by fission-produced neutrons, and bomb-testing. With appropriate modeling the ^{36}Cl contents of groundwater systems give chronological and hydrodynamic information. Accelerator mass spectrometry makes it possible to measure the low levels of ^{36}Cl encountered. S. N. Davis, H. W. Bentley, and P. L. Airey discussed the application of ^{36}Cl measurements to the study of the Great Artesian Basin in Australia and to the Milk River Aquifer in Alberta, Canada.

In the Great Artesian Basin, $^{36}Cl/Cl^-$ ratios decrease systematically from the source to the discharge region. With minor exceptions, the isochrons mapped from the ^{36}Cl ages agree well with isochrons independently calculated from the known hydraulic parameters of the system. The authors interpret the agreement as a strong endorsement of the assumptions of ^{36}Cl groundwater dating.

The Milk River Aquifer behaves differently: Cl^- and ^{36}Cl contents increase with distance from the recharge or source region, while the $^{36}Cl/Cl$ ratio decreases. The authors interpret the concentration increases in terms of ion filtration. The $^{36}Cl/Cl$ ratios yield water ages that exceed estimates from numerical modeling, perhaps because glaciation interrupted the flow patterns for long periods of time. Some dilution of ^{36}Cl by contemporary dissolution of ancient chloride deposits may also occur. This process, too, would increase the calculated ^{36}Cl ages.

^{10}Be & ^{26}Al in Impact Ejecta

The application of cosmogenic radionuclides to the study of impact-produced materials was discussed by G. Raisbeck and F. Yiou. Last year *Pal et al.* [1982] showed that australasian tektites contain $\sim 2 \times 10^8$ atom ^{10}Be g^{-1}. They argued that the ^{10}Be and the tektites formed on earth, but could not entirely exclude the possibility that a small extraterrestrial component, either lunar or meteoritic, carried some ^{10}Be. If the ^{10}Be were extraterrestrial, however, the tektites would also have to contain measureable quantities of other cosmogenic radionuclides such as ^{26}Al and ^{53}Mn. Raisbeck used accelerator mass spectrometry to measure the ^{26}Al contents of several australasian tektites and other impact-related objects. The $^{26}Al/^{10}Be$ ratios observed were consistent with a terrestrial but not an extraterrestrial origin. These observations unambiguously rule out a lunar origin for tektites. Raisbeck also found that other impact-produced materials such as Libyan desert glass contain ^{26}Al in amounts consistent with what cosmic rays would produce on bombarding terrestrial surface matter for $\sim 10^7$ years. He suggested, as have others, that the cosmogenic radionuclides may prove useful in the calculation of surface exposure ages of terrestrial rocks.

Tera presented the ^{10}Be contents of more than 20 australasian tektites and the ^{26}Al contents of six. Again the $^{26}Al/^{10}Be$ ratios were terrestrial. Tera stressed the small range of values observed for ^{10}Be, values which average about 2×10^8 atom ^{10}Be g^{-1}. Sediments harvested from continental margins exhibit a similar, small range of ^{10}Be contents. Soils, in contrast, have ^{10}Be contents that differ markedly from location to location, ranging from 1×10^7 to over 10^{10} atom ^{10}Be g^{-1}. Tera suggests a continental margin for the site of the impact that produced australasian tektites. An origin on a continental margin would accommodate the difficulty specialists have had in identifying a source crater: the crater would have been covered. A margin site may also furnish material from considerable depth with appreciable ^{10}Be content and thus would help explain the uniformity of the data.

Prospects

The advent of accelerator mass spectrometry has greatly facilitated the measurement of such long-lived β-emitters as ^{36}Cl, ^{26}Al, ^{10}Be, and ^{129}I. The new technique obviates the need for fastidious radiochemistry, reduces by 1000 times the minimum sample masses, and gives results in hours rather than days or weeks of counting. Technical advances continue. D. Elmore pointed to prospects for measuring ^{41}Ca and certain stable elements; for example, platinum. Accelerator mass spectrometry may prove helpful in the measurement of solar-neutrino-produced isotopes and in other problems in particle physics that have geologic detectors. Willis outlined progress made by Hurst and coworkers at Oak Ridge in the detection of ^{81}Kr by laser-assisted separation and mass spectrometry. The advance of resonance ionization techniques promises a host of new applications.

K. K. Turekian sounded several cautionary notes. He pointed out that because local deposition rates of the RCN may vary appreciably, certain investigations will require large numbers of measurements to establish clear patterns in the results. The high cost of using the new measurement techniques militates against such surveys except where no cheaper approach exists. Furthermore, gaps in our understanding of the geochemistry of the RCN and of the systems in which they are studied may cloud the interpretation of even the most precise results. For example, diffusion as well as successive laminar deposition may influence the ^{10}Be contents of Mn crusts and nodules.

The foregoing text indicates the wide variety of geophysical problems related to cosmogenic radionuclides. While the less well-known isotopes ^{10}Be, ^{26}Al, ^{39}Ar, ^{81}Kr, and ^{129}I seem unlikely to challenge ^{14}C in importance, they occupy niches that ^{14}C cannot fill. We regard the study of ^{10}Be in volcanic rock as fundamental in importance. The hydrogeological measurements of ^{36}Cl have begun to meet expectations. The analysis of cosmogenic radionuclides in various terrestrial reservoirs augments our knowledge of sedimentary, depositional, and erosional processes. Much of the work described is exploratory. We anticipate that rapid progress in the area will continue.

References

Bucha, V., Archaeomagnetic and paleomagnetic study of the magnetic field of the earth in the past 600,000 years, *Nature*, *213*, 1005, 1967.
Lal, D., and B. Peters, Cosmic-ray produced radioactivity on the earth, in *Handbuch der Physik*, *46/2*, 551–612, 1967.
Monaghan, M. C., S. Krishnaswami, and J. H. Thomas, ^{10}Be concentrations and the long-term fate of particle-reactive nuclides in five soil profiles from California, *Earth Planet. Sci. Lett.*, in press, 1983.
O'Brien, K., Secular variations in the production of cosmogenic isotopes in the earth's atmosphere, *J. Geophys. Res.*, *84*, 423–431, 1979.
Pal, D. K., C. Tuniz, R. K. Moniot, T. H. Kruse, and G. F. Herzog, ^{10}Be in australasian tektites: Evidence for a sedimentary precursor, *Science*, *218*, 787–789, 1982.
Raisbeck, G. M., F. Yiou, M. Fruneau, J. M. Loiseaux, M. Lieuvin, J. C. Ravel, and C. Lorius, Cosmogenic ^{10}Be concentrations in Antarctic ice during the past 30,000 years, *Nature*, *292*, 825–826, 1981.
Reyss, J.-L., Y. Yokoyama, and F. Guichard, Production cross sections of ^{26}Al, ^{22}Na, ^7Be from argon and of ^{10}Be, ^7Be from nitrogen: implications for production rates of ^{26}Al and ^{10}Be in the atmosphere, *Earth Planet. Sci. Lett.*, *53*, 203–210, 1981.
Stuiver, M., Solar variability and climatic change during the current millenium, *Nature*, *286*, 868–871, 1980.

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Opinion

Isotope Instrumentation

Editor's Note: The following commentary is excerpted from the second preliminary report on isotopic instrumentation in geochemistry and mineralogy submitted to the Intersocietal Committee on Instrumentation in Geochemistry and Mineralogy (ICIGM). The report expresses the opinions of one individual (BRD) and in no way is an official expression of the ICIGM. For a copy of the full report write to Bruce R. Doe, 11721 Dry River Ct., Reston, VA 22091.

Accelerator Mass Spectrometry

The Accelerator Mass Spectrometer (AMS) at the University of Arizona, built by General Ionex on the Cockcroft-Walton principle, is reported by Paul Damon to be operating routinely and well at 1.8 MeV. Radiocarbon ages that match or exceed the best underground beta counting facilities are reportedly being produced. Reproducibility is reported to be 1%, a value Damon feels can be improved as they get more experienced in preparing and mounting samples. A second machine at the University of Toronto—built after the initial University of Arizona instrument—is rumored to be operating at 2.5 MeV and Damon is now checking this out. At Arizona they will now convert to trying chlorine-36. The price of the General Ionex machines has risen to about $1.4 million.

Cooperative research with many investigators continues at the University of Rochester tandem Van de Graaf mass spectrometer of which, D. Elmore reports, 20% is funded to do earth science studies. This facility is the most versatile laboratory, with data on chlorine-36 in ice, as well as a variety of beryllium-10 studies, being published. Meyer Rubin has been doing radiocarbon studies there and reports that it is sufficiently well automated that he can run samples by himself so long as nothing goes wrong (i.e., in routine operation, one doesn't have to be an accelerator expert). Analytical uncertainties seem to be about 5% though Rubin feels he is getting about 3% data on radiocarbon. Elmore reports that other kinds of studies are planned such as iodine-129.

The tandem Van de Graaf mass spectrometer at the University of Pennsylvania has been progressing well. Papers by Roy Middleton and colleagues, Loo Brown of the Department of Terrestrial Magnetism (DTM), and Milan Pavich of the U.S. Geological Survey (USGS) and others have involved primarily beryllium-10 in soils and the most exciting paper on volcanic rocks; however, the first application paper by AMS on aluminium-26 has also recently been published. Although this facility is not as well automated as the one at Rochester and must be operated by accelerator experts, R. Middleton is known as the genius of sources (G. F. Herzog of Rutgers University refers to Middleton's "window maker" source as a real advance). Intensity has been increased by a factor of 50 since 1979. As of the time of this report, the University of Pennsylvania/DTM team has yet to sell an earth science proposal to NSF, so all studies so far are "bootlegged" off of particle physics funding but with the knowledge of the funding agency. Small but important support is provided by DTM and the USGS. L. Brown reports that they can have excellent reproducibility on a given day (perhaps 0.1%) but reanalyses a few weeks later may differ by 5%.

Herzog, at the Rutgers University facility has mainly published on extraterrestrial samples but is also interested in lake sediments and pelagic sediments and tektites. As of the time of this writing, he has a grant covering this work.

Time on the Yale tandem Van de Graaf mass spectrometer is severely limited and is bootlegged, but there have been some important papers by Turekian and colleagues on beryllium-10 in manganese nodules. I believe

VGP (cont. on p. 596)

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Cover. Bounded on three sides by water, San Francisco is a delight to travelers and is the site of the annual AGU Fall Meeting, being held this year December 5–9. Housing reservation deadline is November 1. Meeting preregistration deadline is November 10. See Housing and Registration forms in this issue. (Photo courtesy of San Francisco Convention & Visitors Bureau.)

VGP *(cont. from p. 595)*

a thesis on sediments is completed also.

Herzog has pointed out that a tandem Van de Graaf is also operating at the University of Washington (G. Farwell) and that the State University of New York at Stony Brook (A. Champagne) is starting up. I haven't run across any papers from these facilities, however.

A matter that needs mentioning is the itinerant U.S.-non U.S. research efforts. The first paper reporting AMS radiocarbon dates recently appeared in *Science*. This paper was a collaborative effort by a physicist at San Jose State with the AMS group at the Swiss Federal Institute of Technology. T.-L. Ku and colleagues have been doing beryllium-10 studies of manganese nodules with the Toronto AMS group. It appears to be difficult for all the U.S. scientists who wish to participate in the terrestrial cosmogenic radionuclide work to be involved with U.S. AMS facilities, but at least some of those being left out are being resourceful in finding collaborating facilities somewhere in the world. The problem is not restricted to the U.S. scientists. G. M. Raisbeck of France—the person who started it all and had a 2-year head start—has not been able to get on French facilities, so has been collaborating with researchers at U.S. AMS facilities at the universities of Rochester and, more recently, Pennsylvania. Raisbeck is now getting a General Ionex machine, however.

Elmore has pointed out to me that the very important krypton-81 (not formed by spontaneous fission in nature, like chlorine-36) cannot be done by AMS methods because it does not form negative ions. An alternative, laser-based method is being worked on by a consortium involving Scripps, Bern, and Oak Ridge. G. Wasserburg points out that once improved electronics are developed for the Cameca ion probe, it should be ideal for doing aluminum-26, so AMS might not be necessary for it. Therefore, AMS facilities cannot do all the cosmogenic radionuclides, and the relatively less-expensive instruments like the ion probe may be suitable for some others. Although the big tandem Van de Graaf facilities are adequate for the time being to do the first order studies in the frontier scientific areas of terrestrial cosmogenic radionuclides, their expense (more than $1000 per day) and lack of high, long-term precision probably will render them unsuitable at some undefined date in the future. The relatively low-cost General Ionex machine is not yet operating at the 5 MeV mentioned in the specs. Alternatives (desk top cyclotron of Muller, etc.) are not yet developed. Our problem, therefore, is two fold:

(1) We must get funds for terrestrial cosmogenic radionuclide studies, both for scientific investigations and for operation and development of a few existing AMS facilities. Proposals in scientific exploration (where AMS has the best applications) receive hostile peer review in the earth science area of NSF, compared to the normal scientific engineering proposals (where you know a lot and can make a good case for the next step);

(2) We must develop less costly, more precise instrumentation over the next decade.

As bootlegged research and research funded by other agencies or parts of NSF sponsored research by the Physics Division become published and terrestrial cosmogenic radionuclides begin to move into a less pioneering mode, the hostility in the peer review system of the earth sciences community in NSF may begin to evaporate. This development will stress existing NSF budgets in earth science, especially as the interest of the Physics Division can be expected to wane.

I am a little bit uncertain as to what is the proper thing to do for the next step. Certainly I am not competent to render a Delphic decision. I think two things are needed, however: (1) a strategy on how to proceed over the next 10 years or so in this area and (2) some priorities as to where cosmogenic radionuclides should be, relative to the rest of geochemistry and mineralogy.

As for the importance of this research area, I quote from the previous report of June 16, 1982:

This frontier area of geochemistry is not only exciting—for example, it appears from Be-10 studies that sediments are being subducted in many areas—but has great application to societal goals as well. These applications extend from the dating of mineral deposits (many phosphorite deposits thought to be Recent are gradually shown to be Miocene, but they are difficult to date) to the already mentioned groundwater dating for waste storage to ground stability evaluation. In ground stability, there is the dating of both sediments and sedimentation rates, evolution of soils, and dating exposure ages of target rocks. One of the most difficult dating areas involves torrential flooding and land slides and determination of recurrence intervals. Exposure ages are a good way to get at this if the technique works.

In spite of the difficulties, there are an impressive amount of research, number of players, and variety of research at the four main facilities (but mainly Rochester and Pennsylvania), as testified to by the symposium organized by G. F. Herzog at the Baltimore AGU meeting on May 30 (*Eos*, May 3, 1983, pp. 282–284, and the meeting report in this issue of The VGP News). Papers involving AMS were presented on ^{10}Be in lake systems, ^{10}Be and ^{14}C in ice, a beginning on ground water, ^{10}Be in precipitation (2 papers), ^{10}Be in soils and also in erosion and deposition, ^{10}Be in phosphorites and in trade petroleum as well as in a manganese crust and, of course, tektites (2 papers). If I've counted correctly, the symposium involved 36 researchers, some of whom are on more than one paper. The interest is certainly there and should build during the decade.

Bruce R. Doe
Editor, The VGP News

Article *(cont. from p. 593)*

centric coordinates of earth-fixed points, establishment of ties between world datums and determination of polar motion and the earth's gravitational model.

The launching of the first satellite during the IGY and the subsequent launching of dedicated geodetic satellites started a new era of global "datums." DoD was first to solve such a datum in 1960. The solution that became known as the World Geodetic System (WGS) in 1960 thus provided for the first time a "truly" geocentric worldwide coordinate system for global mapping and charting.

5. Gravimetric Investigations

Under the IGY gravity program, DoD played two important roles: first, to participate actively in gravity measurements all over the globe and, second, to provide logistic support to other agencies in remote areas like the Arctic and Antarctic.

The measurement program, besides filling in the gaps where gravity observations were scarce and of doubtful accuracy, included the establishment of first-order stations, the calibration of gravimeters, the verification of the connections between established stations, and the extension of the worldwide gravity net including ocean areas. In remote territories like Antarctica, gravity measurements were also made in conjunction with seismic and glacial studies to improve our knowledge of isostatic compensation in that area.

DoD was also one of the pioneers that recognized the importance of a "combined" solution from surface gravity information and observations of satellite orbit perturbations available from the IGY earth satellite programs. From the initial computation of the third zonal harmonics in early 1959, DoD was among the first to solve a global geopotential model under the World Geodetic System project the following year.

In its logistics support role, the U.S. Navy's ship *The Compass Island* provided a gyro-stabilized platform for the first successful sea surface gravity observations on November 29, 1957. This historic operation thus established that it would be possible to acquire data from over 80% of the earth's surface in the succeeding years. Along similar lines, indispensable airborne and ground support were supplied to the IGY Antarctica gravity traverse teams by a U.S. Navy task force.

6. Geodetic Laser System

The pioneering efforts to develop satellite laser illuminating and ranging techniques were successfully conducted by AFGL in 1963. Also, experiments with corner-cube reflectors (CCR) by the Army Map Service (now DMA) began in the years following the IGY. These are examples of DoD's indirect contribution to geodesy. It is interesting to note that earlier attempts with CCR's were performed with 60-inch searchlight beams. On the basis of the knowledge acquired as a result of the IGY, it is not a surprise that these attempts failed because of large amounts of backscatter.

As the system design progressed, the CCR's were replaced by more efficient retroreflectors. The original concept to measure distances with geodetic accuracy became a reality. We all know that in today's world lasers form the essential ingredient of some of the most accurate and complex geodetic instruments, and the word laser itself has become synonymous with high accuracy geodesy.

7. Summary

On this occasion marking the 25th anniversary of the IGY, this article has recalled some of the DoD activities of the initial years that significantly contributed to the IGY satellite programs involving active, passive, and cooperative satellites.

Today, DoD continues to support the development, enhancement, and application of new technology in such areas as satellite altimetry, airborne gravimetry, gravity gradiometry, inertial surveying, interferometry, charge coupled devices for geodetic astronomy, and others. And, of course, there is a tremendous effort going into the Global Positioning System, which is scheduled to be operational later in this decade.

Time does not allow mention of all the contributions made by DoD components that fulfilled the IGY objectives in satellite geodesy theory, practical methodology of data reduction, satellite tracking techniques and instrumentation, gravimetric investigations, and other basic research. It suffices to say that much of today's technology is a result of the stimulus provided by the dedicated and concentrated efforts begun during the IGY. It has been a fantastic 25 year era for geodesy and for us.

Contributions require people, and while it is not our intent to mention all of those associated with or supported by DoD during this era, the geodetic world will remain beholden to those represented by the likes of the following: the O'Keefes, Kaulas, Chovitzes, Fischers, Leroys, Anderles, Kershners, Weiffenbachs, Newtons, Cohens, Whipples, Heidens, Markowitzes, Winklers, Heiskanens, Uotilas, Muellers, Rapps, Woollards, Talwanis, Williamses, Murrays, Eckhardts, Fitzgeralds, Whittakers, Fallers, Benders, Thompsons, Szabos, Schmids, Mancinis, Gambinos, Martins, Deckers, Ballews, Daughertys, Wilcoxes, Ewings, Whites, Macombers, Schwiderskis.

Acknowledgments. Our appreciation is provided to Muneendra Kumar of the Defense Mapping Agency Hydrographic/Topographic Center, who assisted us with this article.

News

Antarctic Research Priorities Set

Highest priority for future research under the U.S. Antarctic Program should be given to the "extraction of the unique climatic record preserved in the Antarctic ice sheet" and to "the study of the response of marine life to the unique environment at the edge of sea ice." That's the word from the National Research Council's (NRC) Polar Research Board, which was asked by the National Science Foundation (NSF) to recommend priorities for research efforts in the Antarctic. NSF funds the U.S. Antarctic Program. The board ranked eight large-scale research projects in order of priority, identified three smaller, more specific projects that should be included in the U.S. Antarctic Program, and listed other necessary, supportive activities with "widespread implications and applications."

The board says that the best long-term results will be gleaned from the U.S. Antarctic Program with a mixture of the "intensive, integrated, large-scale projects focused on one or more of the principal research questions," the "smaller-scale, lower-cost projects," and "other activities, including ongoing collection and analysis of data, publication of scientific results, and production of maps."

In addition to the two projects tagged as highest priority, the Polar Research Board recommended in its report, *Research Emphases for the U.S. Antarctic Program*, six other large-scale, integrated projects. Very high priority, in the board's view, should go to

- A major interdisciplinary study of the continental margin in the Ross Sea area of Antarctica, involving marine geology and geophysics, oceanography, and marine biology.
- A program of auroral, magnetic, ionospheric, and thermospheric measurements from South Pole Station to develop an understanding of global energy transfer in the magnetospheric cusp and polar cusp.
- An interdisciplinary investigation of the structure and intensity of the Weddell gyre and the impact of the associated fluxes on the climatic, glacial, and biological environment.

High priority was assigned to

- A coordinated program of geophysical studies aimed at understanding West Antarctic crustal structure and history and the dynamics of the ice sheet.
- A multidisciplinary study integrating physical and biological measures to determine the causes for, and ecological consequences of, the swarming behavior of krill.
- A study of the interaction between electromagnetic waves and energetic particles, making use of conjugate-point measurements.

In addition to those eight projects, the board recommended three small projects. The first, designated as very high priority, is studying the life-history patterns and adaptations of the Antarctic biota. The remaining two, assigned high priority, are measuring the heat budget at and around South Pole Station and studying the biogeochemical processes in Antarctic ecosystems.

Other activities within the purview of the U.S. Antarctic Program that the Polar Research Board said should be continued include "the production of topographic and geologic maps; the collection of meteorites; and the monitoring programs at South Pole and McMurdo stations that provide data on upper atmospheric, cosmic, and solar phenomena, earthquakes, and earth tides, constituents of the atmosphere, and standard meteorological data."

To effectively implement the research projects identified, the NRC board said that "support systems permitting longer operating seasons and covering wider geographic areas are required."

Charles R. Bentley, at the University of Wisconsin's Geophysical and Polar Research Center, is chairman of the Polar Research Board. Three ex officio members and four agency liaison representatives complement the 16 scientists who constitute the board. W. Timothy Hushen is executive secretary. —*BTR*

Diamonds at High Pressure

New calculations indicate that diamonds may not have any phase changes at pressures below 23×10^{11} N m^{-2} (23 Mbar) (M. T. Yin and M. L. Cohen, *Physical Review Letters, 50*, 2006, 1983). The importance of this result of course affects the applications of diamonds beyond their value as gem stones. Single crystal diamonds have served as very strong windows for the transmission of a range of radiation spectra in high-pressure experiments. The ultimate strength of diamonds, however, could mark the limit of experiments at 1 Mbar and higher pressures.

A few laboratories have been able to experiment at pressures equivalent to those at the earth's mantle-core boundary (approximately 1.5 Mbar), but such experiments can hardly be considered routine. Extrapolations from experiments done by the General Electric Research Laboratory in Schenectady, N.Y., and by J. A. Van Vechten (*Physica Status Solidi B, 47*, 261, 1971) suggested that diamonds might undergo a phase change at about 1.3 Mbar; if so, diamonds used as window-anvils would fail at the transition. There has been speculation that the phase change would include a reorder of diamond's electronic structure to the metallic state.

Yin and Cohen calculated that a high-pressure transition to the simple cubic structure would occur in diamonds at 23 Mbar. The pseudopotential technique they employed has proven successful in numerous other cases and is becoming a valuable tool in crystal calculations. According to an account by J. Wills of the Clarendon Laboratory, University of Oxford, "Yin and Cohen assumed only the atomic number of the element and the type of crystal structure and then determined the lattice constants, cohesive energies and bulk moduli" (*Nature, 305*, 102, 1983).

The earlier work of Van Vechten had pointed toward a β-tin (tetragonal) crystal structure for the high-pressure carbon phase, in analogy with silicon and germanium. Yin and Cohen obtained consistent results but a different result for the diamond. The 23 Mbar transition pressure bodes well for making experiments above the present 1.5–2 Mbar maximum. The new results say nothing, however, of the yield strength of diamond, which could result in flow or failure at considerably lower pressures.—*PMB*

Real-Time Ionosphere Data

Ionospheric electric fields estimated from observations with the STARE (Scandinavian Twin Auroral Radar Experiment) system have been available in real time since August 1983. Such field information is very valuable. To carry out well-defined experiments in the earth's ionosphere/magnetosphere system, it is desirable to have access in real time to data which define the state of this system. On the principle that no geophysical event is unique, conditions in the ionosphere/magnetosphere are recurrent, and thus the state selected by an experimenter will reoccur eventually; to determine when, experimenters have usually relied on observations that yield information on currents (magnetometers) and charged particle precipitation (riometers, visual auroral data).

STARE consists of two coherent radars with a common field of view covering 200,000 km² of the *E* region over northern Scandinavia. Simultaneous observations of backscatter intensities and Doppler velocities from the two radars allow estimates of the ionospheric electric field with a spatial resolution of 20 × 20 km and a temporal resolution of typically 20 s. The only requirement is that the electric fields exceed a threshold of about 15 mV m^{-1} for generation of radar auroral irregularities (see E. Nielsen and J. D. Whitehead, *Advances in Space Research, 2*, 131, 1983, and R. A. Greenwald et al., *Radio Science, 13*, 1021, 1978).

The radar stations are computer controlled (Data General Nova 2, 16 kilobyte memory) and in continuous operation. Both stations are now equipped with communication software (written by G. Steward, Leicester University, UK) and hardware, which permit them to be reached over the normal telephone system. All parameters governing the radar operations as well as all measurements are transmitted at the end of each integration time. This transmission does not interfere with the normal operation of the radar.

All experimenters desiring access in real time to STARE data are invited to call one or both of the radar stations and to use the transmitted data to help determine when an experiment should be initiated. Should the STARE system be used later in the analysis and interpretation of observations, then a cooperation with the STARE group should be arranged. We believe that this access could be of interest for ground-based experiments, satellite experiments (for example, HEATING, EISCAT, VIKING), and rocket and balloon experiments. Two rocket ranges (ANDOYA and ESRANGE) lie within the STARE field of view.

For more information, contact E. Nielsen, Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, FRG. The STARE system is operated by the Max-Planck-Institut für Aeronomie in cooperation with ELAB, University of Trondheim, Norway, and the Finnish Meteorological Institute, Helsinki, Finland.

Prospecting With Neutrinos

One of the latest attempts to explore the interface between physics and geophysics is the extravagant scheme of Alvaro De Rújula, Sheldon Glashow, Robert Wilson, and Georges Charpak, to be published in *Physics Reports*. In what these theoretical and experimental physicists described recently as "our mad project" (*Physics Today*, August 1983), a high-energy neutrino beam is to be used as a geophysical prospecting tool.

The beam would be able to look for oil, natural gas, and high-atomic-number metal ores, and it would be able to profile the vertical density distribution of the earth. De Rújula et al. come to this project from the world of big physics machines, so it is natural to expect that the "Geotron," the field instrument to supply and focus the neutrino beam, is to be big also.

To their credit, the four particle physicists have worried about the consequences and the costs. They think that the machine could be built for about $1 billion, or even less; however, they concede their real concern is that it would be even more: "it might cost very much more if built under the loving supervision of present-day bureaucrats. The construction could well be drawn out into a jobs-for-all Nirvana for years as the costs double and then double again. This sobering pitfall for projects is not, experience informs us, the exception."

What the neutrino beam really does is to provide a train of acoustical disturbances and nuclear particles along its path as it travels through the earth. The process functions as follows: "When a nucleus hits a nucleus it produces a forward moving shower of charged particles (which ionize the medium) and neutral particles; the neutrals (mainly pions) decay to produce additional ionizing radiation. This sudden deposition of energy, produced in a narrow cone of ionization, produces an acoustical signal."

The neutrinos, whose energies are measured in TeV, are produced by a Geotron, which is an underwater-based synchrotron. The Geotron would provide a proton beam of 10–20 TeV that in turn would impinge upon a target to yield a collimated beam of pions and kaons that would undergo decay as mesons to neutrinos. This process of conversion would be tightly collimated in a tunnel called a Snout. The Snout is actually a flexible tube that holds a series of superconducting magnets. Even at a distance of 1000 km the low divergence of the neutrino beam would result in a radius of only 10 m.

GENIUS (Geological Exploration by Neutrino-Induced Sound), is the application of the Geotron to locate petroleum deposits at great distances. At 1000 km an array of geophones with frequency ranges of 1–100 Hz would be tuned in on the acoustical beam and at the same time filter background and seismic noise. Enormous areas can be surveyed and at great depth (the signal energy falls off with the first rather than the fourth power of depth, as with seismic waves).

It also would be feasible, according to the proposed plan, to measure the muon beam. Thus GENIUS would become GEMINI (Geological Exploration with Muons Induced by Neutrino Interaction). Muon sensors could detect differences as the beam passed through high-atomic-number metal concentrations.

A crucial property of the beam in all applications is that it can penetrate the entire earth. In the Geoscan mode a special, vertically oriented beam of neutrinos would be aimed at the earth in such a way that it would travel through the center of the earth, penetrating the core. Muon detectors would sample the beam at various angles. It should be possible to obtain a determination of the earth's radial density distribution to high accuracy in a short time.

The project is being proposed as a selling point for construction of the Texatron, the huge hadron collider accelerator that has been suggested for the Texas A&M campus. The Texatron could provide a neutrino beam that would be used to test these ideas of geophysical exploration.—*PMB*

China's Petroleum Reserves

Perhaps because of declining yields inland, the People's Republic of China has moved to its storm-ridden coast to develop additional petroleum reserves. During 1979 and 1980, 44 foreign oil-exploration companies engaged in what has been termed the world's record "seismic shoot" over 411,000 km² extending from the Yellow Sea through the South China Sea, and including Beibu Wan (Gulf of Tonkin), the bay lying east of Hanoi and west of Hainan Island. These offshore oil reserves are estimated to be 40–100 billion barrels.

The seas off the mainland are relatively shallow (most drilling has been done in less than 110 m) but they are stormy. According to a recent description, "Typhoons can . . . occur in the area at almost any time of the year, and the strong winds (160 km h^{-1} or more) which they generate frequently wreak havoc in the Philippines, Vietnam, China, and occasionally, Hong Kong. Typhoon Vera, which hit southern China in late July, did immense damage and claimed dozens of lives. The main implications for oil operation naturally relate to rig design and safety measures but onshore facilities will also have to be designed accordingly" (*New Scientist*, Sept. 8, 1983).

Exploration and drilling techniques similar to those used in the North Sea, although to shallower depths, are being used. The political boundaries will not be so easily settled, however. The China Sea and its islands are a great potential source of political conflict, the entire area being claimed by mainland China, the Philippines, Taiwan, Vietnam, and others.—*PMB*

Nominations for Medals and Awards

William Bowie Medal. Awarded for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Maurice Ewing Medal. Honors an individual who has led the way in understanding the physical, geophysical, and geological processes in the ocean; who is a leader in ocean engineering, technology, and instrumentation; or who has given distinguished service to the marine sciences.

Robert E. Horton Medal. Given for outstanding contributions to the geophysical aspects of Hydrology.

James B. Macelwane Awards. Up to three awards are given each year for significant contributions to the geophysical sciences by a young scientist of outstanding ability. Recipients must be less than 36 years old.

Letters of nomination outlining significant contributions and curriculum vitae should be sent directly to the appropriate committee chairmen: *Bowie Medal* - Eugene M. Shoemaker, U.S. Geological Survey, 2255 Gemini Drive, Flagstaff, AZ 86001; *Ewing Medal* - Robert O. Reid, Department of Oceanography, Texas A&M University, College Station, TX 77843; *Horton Medal* - R. Allan Freeze, Department of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1W5; *Macelwane Award* - J. Freeman Gilbert, IGPP A-025, University of California/San Diego, La Jolla, CA 92093.

Deadline for Nominations is November 1, 1983.

Society Merger Rejected

Members of the American Society of Photogrammetry (ASP) and members of the American Congress on Surveying and Mapping (ACSM) have rejected a plan to consolidate the two societies.

An affirmative vote of at least two-thirds of each society's members present or represented by proxy was required for the merger. Voting in favor of the consolidation plan were 61.2% of ASP voters and 63.7% of ACSM voters. Almost 50% of eligible members of each society participated in the September 21 vote.

The consolidation had been discussed for several years and was formally proposed in June 1981. In September 1981 the two societies agreed to affiliate (*Eos*, November 10, 1981, p. 765) and agreed to prepare a consolidation plan. Although the consolidation was rejected last month, the societies will retain their affiliation. As affiliated societies, they are located in the same building in Falls Church, Va., and share a single governmental affairs program and an educational program.

JOI Seeks Nominations

Joint Oceanographic Institutions (JOI), Inc., is seeking nominations for a new panel to coordinate scientific ocean drilling. To be called the U.S. Science Advisory Committee (USSAC), the panel would complement the work of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES).

The Board of Governors of JOI says it wants USSAC to include broad representation from academic, government, and industry sectors outside the 10 JOI member institutions, and it is inviting nominations, including a brief vita and list of publications, for membership on USSAC to be sent, by November 3, to John H. Clotworthy, JOI, Inc., 2100 Pennsylvania Ave., N.W., Suite 316, Washington, DC 20037.

Geophysicists

Richard C. Hart is the new secretary of the U.S. National Committee for the Committee on Space Research (COSPAR). Hart succeeds *Dean Kastel*, who is now the executive secretary of the National Research Council's Space Science Board. In addition to his new duty with COSPAR, Hart serves as the staff officer for the Space Science Board committees on space astronomy and astrophysics, solar and space physics, and data management and computation.

John H. McElroy was recently appointed assistant administrator for the National Environmental Satellite, Data, and Information Services of the National Oceanic and Atmospheric Administration. McElroy had been acting assistant administrator since February 1982.

Timothy D. Steele has accepted a position as water resources manager of the Denver office of In-Situ, Inc., a high-technology consulting company serving the mining and energy industries. Steele previously worked for more than 13 years with the U.S. Geological Survey's water resources division. Most recently, he was chief of the water quality group in the Denver office of Woodward-Clyde Consultants.

Recent Ph.D.'s

Eos periodically lists information on recently accepted doctoral dissertations in the disciplines of geophysics. Faculty members are invited to submit the following information, on institution letterhead, above the signature of the faculty advisor or department chairman: the dissertation title, author's name, name of the degree-granting department and institution, and month and year degree was awarded. If possible include the current address and telephone number of the degree recipient (this information will not be published).

Methane and Radioactive Isotopes in Submarine Hydrothermal Systems, Kyung-Ryul Kim, Scripps Institution of Oceanography, Univ. of California, San Diego, June 1983.

The Oceanographic and Geoidal Components of Sea Surface Topography, Victor Zlotnicki, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, June 1983.

Vorticity and Upwelling Near an Isolated Feature on the Continental Shelf, Stephen M. Chiswell, Marine Sciences Research Center, State Univ. of New York, Stony Brook, August 1983.

Effects of Size, Age and Photoperiod on Hypoosmoregulation in Brook Trout Salvelinus Fontinalis, Stephen D. McCormick, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Foraminiferal Trace Elements: Uptake, Diagenesis, and 100 m.y. Paleochemical History, Margaret L. Delaney, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Processing and Inversion of Arctic Ocean Refraction Data, Gregory L. Duckworth, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Purification and Characterization of the Hepatic Microsomal Monooxygenase System from the Coastal Marine Fish Stenotomus Chrysops, Alan V. Klotz, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Wave-Induced Turbulent Flow Near a Rough Bed: Implications of the Time-Varying Eddy Viscosity, John H. Trowbridge, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Effects of Pore Pressure, Confining Pressure and Partial Saturation on Permeability of Sandstones, Joel Dan Walls, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., January 1983.

Relative Motions Between Oceanic and Continental Plates in the Pacific Basin, David Cal Engebretson, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., January 1983.

Velocity, Attenuation, and Natural Fractures in Shallow Boreholes, Daniel B. Moos, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., January 1983.

A Study of the Seismic Structure of Upper Oceanic Crust Using Wide-Angle Reflections, Kristin M. M. Rohr, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, February 1983.

Spectral Reflectance of Near-Earth Asteroids: Implications for Composition, Origin and Evolution, Lucy A. McFadden, Dept. of Geology and Geophysics, Hawaii Institute of Geophysics, Univ. of Hawaii, May 1983.

Dip-Moveout by Fourier Transform, Ira David Hale, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., June 1983.

Flow and Skin Friction over Natural Rough Beds, Christopher Paola, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, June 1983.

Migration of Reflection Seismic Data in Angle-Midpoint Coordinates, Richard Albert Ottolini, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., June 1983.

New Techniques in the Analysis of Geophysical Data Modelled as a Multichannel Autoregressive Random Process, P. A. Tyraskis, Laboratory in Applied Geophysics, Dept. of Mining and Metallurgical Engineering, McGill Univ., Montreal, Canada, June 1983.

Spatial Coherency of Seismic Waveforms, Keith McLaughlin, Dept. of Geology and Geophysics, Univ. of California, Berkeley, June 1983.

Wave Propagation in Porous Rock and Models for Crustal Structure, Terry Dean Jones, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., June 1983.

Books

An Introduction to Crystal Optics

P. Gay, Longman, New York, ix + 262 pp., 1982, $14.95.

Reviewed by Donald E. Sands

An Introduction to Crystal Optics is a reprinting in paperback of a book first published in 1966. The preface states that the only modification made in this version is an updating of the bibliography; however, a comprehensively revised edition is promised "before long."

The book is essentially a treatment of classical optical crystallography, little touched by twentieth century science. The tone is descriptive and qualitative, equations are rare, and the physics tends to be superficial. If physics is not its forte, descriptive clarity is. This little volume is recommended for its well-written exposition of the study of crystals with the aid of the polarizing microscope. It will serve as an excellent introduction to microscopy or optical mineralogy. It will also be useful to the advanced reader seeking elementary explanations of what other works treat in a more erudite manner.

The first five chapters discuss the properties of light and its transmission through crystals. The wave character of light is described by analogy to water waves. The Huygens' construction is applied to the analysis of wave motion through isotropic media. After introducing optical anisotropy via the transmission of light through calcite, the Huygens' construction is extended to uniaxial crystals. The indicatrix is presented as an aid to understanding the transmission of light through crystals of any symmetry. Absorption in anisotropic media, dispersion, and pleochroism are covered in a brief chapter.

These presentations of the properties of light are followed by six chapters of a practical nature, treating the production of polarized light, the polarizing microscope, microscopic methods of measuring isotropic refractive indices, interference effects in parallel light and in convergent light, and dispersion of the indicatrix. The final, and longest, chapter shows how to apply the principles of the preceding chapters to microscopic observations. Relegated to appendices are the geometric properties of the indicatrix, the analysis and superposition of waves, the minimum deviation and the critical angle methods of measuring refractive indices, and optical activity.

Exercises accompany most chapters. A few of these are simple numerical problems, for which answers are supplied at the end of the book, but many are laboratory exercises requiring the use of a polarizing microscope.

Donald E. Sands is with the University of Kentucky, Lexington, KY 40506–0032.

Mount St. Helens Eruptions of 1980: Atmospheric Effects and Potential Impact

NASA SP-458, R. E. Newell and A. Deepak (Eds.), NASA Scientific Information Branch, Washington, D. C., 119 pp., 1982.

Reviewed by R. Reiter

This clearly and uniformly arranged little book reports the results of a NASA workshop held November 20–21, 1980, in Washington, D. C., on the atmospheric effects of the 1980 Mount St. Helens eruptions.

It is divided into the following six chapters: (1) Volcanological Description of the May 18, 1980, Eruption of Mount St. Helens, (2) Transport and Dispersion, (3) Chemical and Physical Measurements of the Volcanic Cloud Made In Situ, (4) Remote Sensing of Mount St. Helens Effluent, (5) Chemistry of the Mount St. Helens Effluent, and (6) Influence of Mount St. Helens and other Volcanoes on Climate and Weather. Each chapter closes with conclusions and references.

The single chapters give a brief and clear description of the knowledge of the volcanic eruption itself; the resultant loading of the stratosphere with ejecta; the to-be-expected chemical processes in the stratosphere caused by the eruptive material; the eruptive material's time behavior; and the transport and diffusion processes.

In addition, the book gives a detailed description of remote sensing of Mount St. Helens effluent, including satellite-based measurements (SAGE, SAM II), lidar systems, and methods of radiation measurements. Lidar results from stations in Europe and Japan are used in graphs, unfortunately without references.

A special chapter is devoted to the potential impact on weather and climate of the Mount St. Helens eruption (the strongest eruption since Fuego in 1974). A possible stratospheric warming and cooling of the earth's surface is tentatively suggested. Most prominent in the recommendations of this chapter is the need for long-term measurements of the stratospheric background in order to acquire precise knowledge of the undisturbed conditions prior to future eruptions. Such eruptions were not long in coming: Alaid in 1981 and, in 1982, the massive eruption of El Chichón, whose terrestrial impacts can certainly no longer be neglected.

Mount St. Helens' eruption was thus an impressive reason for many researchers to prepare themselves for the eruptions of the recent past: That is the sense in which this book must be regarded as very useful, although, considering the totally changed atmospheric conditions due to El Chichón's eruption, no longer quite up to date. The book's text and illustrations (30 of them, many in color) are well printed and it should be available in the libraries of all engaged or interested in research on the global atmospheric process.

Yet, at the end, a remark: Right before the workshop on the topics of the book under review, another NASA symposium was held November 18–19, 1980, also in Washington, D. C. The title was almost the same and the scientists in attendance were 3 times more numerous; the papers are printed in their entirety as NASA Conference Publication 2240. The volume has 303 pages, approximately 180 figures, and very complete references. It is only in part identical with the book under review and it, too, deserves special attention.

R. Reiter is with the Fraunhofer-Institute for Atmospheric Environmental Research, D-8100 Garmisch-Partenkirchen, Federal Republic of Germany.

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Statistics on Spheres, G. S. Watson, John Wiley, New York, x + 238 pp., 1983, $21.50.

Stellar and Planetary Magnetism, vol. 1, *The Fluid Mechanics of Astrophysics and Geophysics*, A. M. Soward (Ed.), Gordon and Breach, New York, xi + 375 pp., 1983, $69.50.

To Quench Our Thirst: The Present and Future Status of Freshwater Resources of the United States, D. A. Francko and R. G. Wetzel, Univ. of Michigan Press, Ann Arbor, viii + 148 pp., 1983, $8.50.

Underground Sound: Application of Seismic Waves, J. E. White, Elsevier, New York, xvi + 254 pp., 1983, $59.50.

Variations in the Global Water Budget, Symposium on Variations in the Global Water Budget, Oxford, 1981, A. Street-Perrott, M. Beran, and R. Ratcliffe (Eds.), D. Reidel, Boston, xiv + 518 pp., 1983.

World Ocean Atlas: Arctic Ocean, Introduction and Index, Pergamon, New York, xx + 41 pp., 1983.

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Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D. C. 20009.

For further information, call toll free 800-424-2488 or, in the Washington, D. C., area, 462-6903.

POSITIONS AVAILABLE

North Carolina State University/Marine Chemist. The Department of Marine, Earth, and Atmospheric Sciences invites applications for a 9 month, tenure track position at the assistant or associate professor level. The candidate must have a Ph.D. and will be expected to interact with various research programs within the department such as: radiochemistry, stable isotope and trace metal geochemistry, sedimentology, ocean circulation, air-sea interaction, and biological oceanography. Responsibilities include conducting a viable research program as well as teaching and advising graduate students. Applicants should forward a resume and the names of at least three references to: Dr. David J. DeMaster, Chairman, Search Committee, P.O. Box 5068, North Carolina State University, Raleigh, NC 27650. Application material should be sent by November 30, 1983.

North Carolina State University is an equal opportunity/affirmative action employer.

Florida International University/Faculty Position in Geology. The Geology program at Florida International University is expanding and plans to increase its faculty in the next few years. In order to complement existing instructional and research strength, the University invites applications for tenure track positions at the Assistant Professor level in the following areas of specialization:

1. Igneous Petrology/Geochemistry/Economic Geology
2. Geophysics/Marine Geology
3. Stratigraphy/Sedimentology

Successful applicants must have demonstrated an ability for high quality teaching and the potential to establish a productive research program in the area of specialty. Subject to final approval of funding, appointments will begin in August 1984. Deadline application is February 2, 1984. Send a resume, brief description of teaching experience and research interest, transcripts, and three letters of reference to:

Dr. L. Keller, Chairman
Department of Physical Sciences
Florida International University
Tamiami Trail
Miami, FL 33199

Florida International University is an affirmative action/equal opportunity employer.

National Center for Atmospheric Research/Visitor Applicants. At the High Altitude Observatory, Visitor Appointments are available for new and established Ph.D.'s for up to one year periods to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicants should provide a curriculum vitae including education, work experience, publications, the names of three scientists familiar with their work, and a statement of their research plans. Applications must be received by January 15, 1984, and they should be sent to: HAO Visitor Committee, High Altitude Observatory, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307.

NCAR is an Equal Opportunity/Affirmative Action Employer.

Assistant or Associate Professor/The Chesapeake Biological Laboratory (CBL) of UMCEES. Applications invited for a tenure-track faculty position in marine or estuarine chemistry or geochemistry. The successful candidate will develop a program of research in their own field of interest; will play an important role in a growing program of chemistry and geochemistry at CBL, and will participate in interdisciplinary research programs with other scientists with specialties in chemistry, sedimentology, and physical and biological oceanography. Some preference will be given to candidates with interests in trace or major element geochemistry or organic geochemistry, particularly in relation to sediments. However, all candidates with interests in the broad subject areas are encouraged to apply.

Applicants should have a strong post-doctoral research record, demonstrated interests in interdisciplinary research, and an interest in teaching and graduate research. Curriculum vitae, description of research interests and a list of three to five references should be sent to: Dr. Jay C. Means, Chairman—Search Committee, UMCEES, Chesapeake Biological Laboratory, Box 38, Solomons, Maryland 20688–0038. Applications received by October 31, 1983 will be assured full consideration.

The University of Maryland is an Affirmative Action/Equal Opportunity Employer.

Atmospheric Dynamics and Planetary Physics/The Johns Hopkins University. The Department of Earth and Planetary Sciences intends to make a tenure-track faculty appointment in each of these areas, one in July 1984 and the other in July 1986. The Atmospheric Dynamics post will be at the Assistant Professor level; applicants should have a demonstrated capacity for innovative research with, preferably, post-doctoral experience. The appointment in Planetary Physics will be made at a level commensurate with the attainments of the successful candidate; for appointment as full professor, a high international reputation for research accomplishments is expected. Women and minority candidates are especially encouraged to apply.

It is expected that the appointees will develop programs in teaching and research that will complement the activities of the present groups in geophysical fluid dynamics and geophysics, whose research interests include turbulence, waves, air-sea interactions, stratified flow dynamics, convection, mesoscale meteorology, dynamics of the earth's interior, and volcanology. The appointee in planetary physics will be encouraged to interact strongly with scientists at the Space Telescope Science Institute, which is on campus. The University is a member of the University Corporation for Atmospheric Research.

Applications should include a curriculum vitae, copies of one or two recent publications and the names of at least three referees. They should be sent by January 15, 1984 to Professor O.M. Phillips, Chairman, Search Committee, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, Maryland 21218.

The Johns Hopkins University is an Equal Opportunity Employer.

Meteorologist/The City College of The City University of New York. The Department of Earth and Planetary Sciences invites applications for an anticipated opening in meteorology. The appointment will start September, 1984. Applicants should have completed the Ph.D. by the time of appointment and have a strong background in synoptic meteorology and computer applications. In addition, the individual should have an interest in atmospheric chemistry or pollution as applied to urban areas, or physical oceanography. The person hired will be required to teach courses in meteorology, and possibly physical oceanography as well as develop and maintain an active research program. Participation in the C.U.N.Y. Ph.D. Program in Earth and Environmental Sciences is anticipated. Rank and salary will be commensurate with experience. Send resume, transcripts and three letters of reference by November 30, 1983 to Professor Dennis Weiss, Chairman, Department of Earth and Planetary Sciences, the City College, 138 Street and Convent Avenue, New York, N.Y. 10031.

The City College of the City University of New York is an equal opportunity affirmative action employer.

Research Associate Position in Cratering Mechanics/University of Arizona. A position is open for a young scientist interested in applying physical principles to the mechanics of impact cratering and studying the origin of meteorites, the morphology of large craters or the climatic effects of a large terrestrial impact. The applicant should have a Ph.D. in geophysics or a related field. Experience with large numerical codes is desirable. A resume and three letters of reference should be sent to: H. J. Melosh, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721. All applications must be received by Nov. 1, 1983.

The University of Arizona is an equal opportunity employer.

Louisiana State University/Chas. T. McCord, Jr. Endowed Professorship in Hydrocarbon Exploration. The Geology Department is seeking an internationally recognized leader in some research specialty critical to the search for oil and gas to fill the Chas. T. McCord, Jr. Endowed Professorship. Applicants are expected to maintain scholarly research in their area of specialty. Rank at Full Professor level with salary competitive with endowed professorships at other major research universities. For consideration send resume, three letters of reference, and a description of future research programs to Lyle McGinnis, Faculty Search, Department of Geology, Louisiana State University, Baton Rouge, LA 70803–4101. Search will remain open until position is filled.

LOUISIANA STATE UNIVERSITY IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER.

Washington University, St. Louis. Washington University, St. Louis, announces tenure track positions for the fall of 1984. Preference is for candidates in Geophysics, Structural Geology, Metamorphic Petrology, or Petrology of Extraterrestrial Materials.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references to Larry A. Haskin, Chairman, Department of Earth and Planetary Sciences, Washington University, St. Louis, Missouri 63130. Applications received through January 1, 1984.

Washington University is an equal opportunity/affirmative action employer.

North Dakota State Water Commission/Geohydrologist. To work in aquifer evaluation and management. Bachelor's degree with two years experience or masters degree with experience in quantitative techniques required. Background in watershed modeling, soil physics or unsaturated flow processes desired. Salary range $1555-$2278 per month. Send resume to:

North Dakota State Water Commission
Hydrology Division
900 East Boulevard
Bismarck, North Dakota 58505

North Dakota State Water Commission is an equal opportunity/affirmative action employer.

The University of New Mexico/Research Associate. Applications are invited for a permanent position as a research associate in the Department of Geology at The University of New Mexico. The applicant should have experience in characterizing the structure, morphology and chemistry of solid materials with the analytical electron microscope (to be purchased this year) and will be responsible for the day-to-day operation of the instrument. The work will involve the characterization of metallic, ceramic and composite materials, including rock-forming minerals. The scanning transmission electron microscope will be part of an Electron Microbeam Analysis Facility which includes a fully-automated ARL EMX-SM electron microprobe; an automated, five spectrometer, 733 JEOL Superprobe and an Hitachi 450 scanning electron microscope. Each instrument has an EDS and is housed in newly constructed laboratories. Experience in x-ray diffraction crystallography and secondary x-ray fluorescence analysis would be useful.

The successful applicant is expected to maintain his/her own active research program and to interact with faculty throughout the University in cooperative materials science research.

A Ph.D. is required and the salary is in the range of $27,000 to $35,000/12 months commensurate with experience. Applicants should forward a detailed resume to R. C. Ewing, Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131. Deadline for applications is December 15, 1983.

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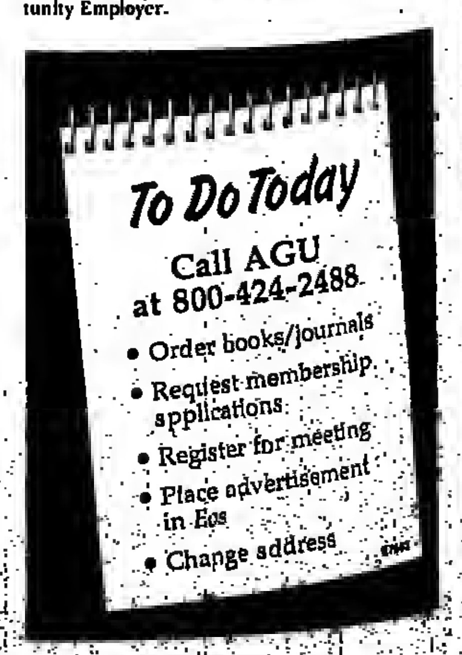


October 18, 1983 EOS

University of Florida. The Department of Geology invites applications for a tenure-track position beginning with the fall term, 1984. The position will be filled at the assistant or associate professor level. A Ph.D. is required and salary will be commensurate with qualifications. Although any research specialty will be considered, preference will be given to those with interest in these general areas: geochronology-isotope geology or low-temperature geochemistry-chemical sedimentology. Send curriculum vitae and 3 letters of reference by January 15, 1984 to: Dr. N.D. Opdyke; Department of Geology; 1112 GPA; University of Florida; Gainesville, Florida 32611.

The University of Florida is an equal opportunity/affirmative action employer.

Faculty Position in Geology/University of Puget Sound. Tenure-track Assistant Professor. Field-oriented Geomorphologist with strong interest in Quaternary glacial stratigraphy and landscape processes; to begin February 1, 1984 or September 1, 1984; salary commensurate with experience. The department (3 career faculty) has long established, successful undergraduate program with joint faculty/student research. Team teach Physical Geology—Topics (all three faculty teach both lecture and labs), and teach a senior level Geomorphology course (lecture and lab) with a process and quantitative focus, including computer applications (Fall). Teach Physical Geology (lecture and lab) and share teaching responsibilities in Historical Geology (Spring). Participate in departmental/University governance, advise students, and continue professional development. Ph.D. in Geology, ability to teach both majors and non-majors, and ability to carry out cooperative, interdisciplinary research with undergraduate geology and other science majors. (Additional info available at Indianapolis GSA meetings.) Submit detailed vita, statement of short- and long-term career objectives, transcripts, and names of three references by November 10, 1983, to: Geology Search, University of Puget Sound, P.O. Box 7293, Tacoma, WA 98407.

An Equal Opportunity, Affirmative Action Educator/Employer.

Postdoctoral Position. Available for the experimental study of the entrainment, deposition, and transport of sediments in lakes and oceans. The research will be primarily in the laboratory but will also involve some field work. Competence in experimental fluid mechanics and interest in environmental problems is necessary. The position will remain open until filled. Applicants should send resume and names of three references to:

Professor Wilbert Lick
Department of Mechanical & Environmental Engineering
University of California
Santa Barbara, CA 93106

An Equal Opportunity/Affirmative Action Employer.

Postdoctoral Awards in Ocean Science and Engineering. Woods Hole Oceanographic Institution invites applications for 1-year postdoctoral scholar awards from new and recent doctorates in fields of biology, chemistry, engineering, geology, geophysics, mathematics, meteorology, and physics, as well as oceanography. Recipients of awards are selected on a competitive basis, with primary emphasis placed on research promise.

Fellowship stipend is $22,000. Appointees are eligible for group health insurance and a modest research budget. Recipients are encouraged to pursue their own research interests independently or in association with resident staff. Completed applications must be received by January 1, 1984 for 1984–85 awards. Awards will be announced by March 1st. Write for application forms to: *Dean of Graduate Studies, P.O. Box E, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.*

Equal Opportunity/Affirmative Action Institution.

Ohio State University/Seismologist-Tectonophysicist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a geophysicist with research interests in seismology and/or tectonophysics. The successful applicant must be prepared to assist in teaching exploration geophysics courses, advanced topics in his/her speciality, conduct research, and supervise graduate students. Preference will be given to candidates with post-doctoral or industrial experience. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-6349 or 422-2721

Applications should include a resume, a statement of research interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

Earth Sciences

The Lamont-Doherty Geological Observatory of Columbia University invites scientists interested in any field of the earth sciences to apply for the following fellowships: Two postdoctoral fellowships, each awarded for a period of one year (extendable to two years in special instances) beginning in September, 1984 with a stipend of $25,000 per annum.

Completed applications are to be returned by January 15, 1984. Application forms may be obtained by writing to the Director, Lamont-Doherty Geological Observatory, Palisades, New York 10964. Award announcements will be made February 28, 1984, or shortly thereafter.

Columbia University is an Affirmative Action/Equal Opportunity Employer.

Ohio State University/Paleobiologist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a paleobiologist with a strong quantitative background; and the capacity to develop or expand a research program in biogeography, evolutionary paleobiology, functional morphology, or paleoecology that will augment existing programs in biostratigraphy, micropaleontology and sedimentary petrology.

Ph.D. or equivalent is required by the time of appointment. The successful applicant will be expected to teach graduate and undergraduate courses appropriate to their expertise, conduct research and supervise graduate students. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Walter C. Sweet
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-2326 or 422-8746

Applications should include a resume, a statement of research record and interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

Ohio State University/Structural Geologist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a structural geologist with a strong background in quantitative analysis of field data and research interests in regional tectonics or tectonophysics. The successful applicant will be expected to participate in the undergraduate program and give graduate courses in his/her field of expertise, conduct research, supervise graduate students, and interact with other departmental programs in regional geology and geophysics. Preference will be given to candidates with post-doctoral or industrial experience. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-5635 or 422-2721

Applications should include a resume, a statement of research interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

The State University of New York at Binghamton/Petrologist. The State University of New York invites applications for a tenure-track faculty position in igneous or metamorphic petrology beginning August, 1984. Appointment will be at the level of assistant professor. Candidates must have a Ph.D. degree by this date, and also the potential to develop a productive research program, as well as teach at the undergraduate and graduate levels.

Applicants should send a resume and names of at least three persons who can be contacted for references to:

Thomas W. Donnelly
Department of Geological Sciences
State University of New York
Binghamton, New York 13901

The State University of New York at Binghamton is an affirmative action/equal opportunity employer. The closing date for this position is December 15.

Reflection Seismologists or Geologists. Bored by oil? BIRPS—academic seismic profiling at sea to 15 seconds—seeks postdocs for geological interpretation and innovative processing. Splendid environment. University salary. Send cv to Dr. Matthews, Earth Sciences, Bullard Labs, Cambridge University, England.

Assistant/Associate Professor (Ocean Engineering). Tenure-Track Position beginning 1984–1985 academic year. Preference given to candidates with expertise in 1 or more of the following areas: offshore and coastal structures, acoustic imaging (including sediment studies), oceanographic remote sensing, wave dynamics sediment transport. Must establish an active sponsored research program, teach graduate courses in area of specialization and supervise graduate student research. Ph.D. or equivalent degree in specialty area required. Send resume, names and addresses of 3 references and a description of career goals by May 1, 1984 to: Dr. Malcolm L. Spaulding, Chairman Search Committee, Department of Ocean Engineering, UNIVERSITY OF RHODE ISLAND, Kingston, R.I. 02881–0814.

An AA/EOE M/F.

Department of Geosciences/University of Houston. The Department of Geosciences is interested in having applications for tenure track positions in the following areas: (1) Geophysics—seismology, exploration, data processing (2) Petrology—sandstones and metamorphic (3) Geochemistry—diagenesis

Salary and rank commensurate with experience. If interested, please send:

(1) A curriculum vitae
(2) A brief statement of teaching and research interests
(3) Three letters of recommendation to:

Dr. John C. Butler
Department of Geosciences
University of Houston
Houston, Texas 77004

Affirmative-action/equal-opportunity employer.

Louisiana State University/Tenure-Track Faculty Positions in Geology. The Department of Geology is expanding from 13 to 35 faculty with four positions open Fall 1984 and one position (Field Camp Director) open January 1984. Candidates must have the Ph.D. and have active research in progress that might be applied to studies of basins. Specialties of primary interest are field geology, theoretical seismology, hydrogeology, and organic geochemistry; however, other disciplines will also be considered with quality of research being the primary factor in applicant selection. All faculty in the Department are required to conduct research leading to publications and to provide quality instruction. The Department will expand into a new building January 1986.

For consideration send resume, three letters of reference and a description of research to Lyle McGinnis, Faculty Search, Department of Geology, Louisiana State University, Baton Rouge, LA 70803–4101. Search will remain open until positions are filled.

LOUISIANA STATE UNIVERSITY IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER.

Post-Doctoral Position in Isotope Geochemistry. Department of Geology and Geophysics/University of Minnesota. Applications are invited for a postdoctoral appointment in geochemistry starting January 1, 1984. The candidate should have research interests and training in igneous petrology and isotopic and trace element geochemistry. The appointee is expected to work on problems related to mantle geochemistry and magma genesis, by application of Sm-Nd and Rb-Sr isotopic techniques and trace element geochemistry. Prior experience in solid source mass spectrometry is desirable. The duration of the initial appointment is for one year, with opportunities for renewal for a subsequent year or two. Starting salary is in the range of $17,000 to $19,000, based on previous experience. Candidates should submit a resume with the names of three references as well as a brief statement of research interests to:

V. Rama Murthy
Dept. of Geology and Geophysics
University of Minnesota
310 Pillsbury Drive S.E.
Minneapolis, MN 55455

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Cornell University Department of Geological Sciences. Applications are invited for a tenure-track position at the assistant professor level to begin in Fall 1984. Specialties of interest are sedimentology, stratigraphy, and structural geology. Some experience beyond the Ph.D. is desirable. Send curriculum vitae and names of three references to

Donald L. Turcotte, Chairman
Department of Geological Sciences
Kimball Hall
Cornell University
Ithaca, New York 14853

Cornell University is an Equal Opportunity Employer.

Physicist/Math Analyst. Sigma Data Services Corp., an M/A-COM Co., has an immediate opening for a Physicist/Math Analyst. Master's degree or equivalent experience in magnetospheric physics or solar terrestrial physics is required. Experience with spacecraft or rocket trajectory calculations is desired. Must have working knowledge of FORTRAN and have at least three years experience in the use of computers for data reduction or mathematical analysis. Duties include enhancement of existing programs, analysis, development, and implementation of new capabilities for determining multi-satellite, ground station, and magnetospheric model interactive data acquisition and analysis. Send resume to Dr. H. K. Hills, Sigma Data Services Corp., NASA/GSFC, Code 601, Greenbelt, Md. 20771 or call (301) 344-8105.

University of Alaska/Exploration Geophysicist—Seismic Stratigrapher. Applications are invited for a tenure-track teaching/research position in the Geology/Geophysics Program of the College of Environmental Sciences. Prime responsibilities will be to teach graduate and some undergraduate courses in the use of state-of-the-art techniques in petroleum exploration geophysics. The successful applicant will also develop an innovative research program to complement our growing petroleum geology curriculum. Doctorate is required. Industrial experience in hydrocarbon exploration and, in particular, the use of seismic reflection data to interpret stratigraphic and facies is desirable. The nine-month faculty position is open starting in January 1984. Rank and salary commensurate with qualifications and experience. Resume and at least three references should be submitted to Dr. Juan G. Roederer, Director, Division of Geosciences, University of Alaska, Fairbanks, Alaska 99701. Applications will be accepted until December 15, 1983 or until position is filled.

Your application for employment with the University of Alaska may be subject to Public Disclosure if you are selected as a finalist.

The University of Alaska is an EO/AA employer and educational institution.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

Iowa State University is an equal opportunity/affirmative action employer.

NASA NSSDC/ACQUISITION SCIENTISTS

Sigma Data Services Corp. a M/A-COM Company, as contractor operating the National Space Science Data Center (NSSDC) at NASA/GSFC, has immediate openings for scientists in the following disciplines:

—Astronomy/Solar Astronomy/Astrophysics (especially X-ray)
—Remote sensing/Meteorology/Atmospheric Sciences
—Lunar/Planetary Geology/Planetology
—Magnetospheric Physics

M.S. required, PhD preferred. Candidates should have experience in analysis of data from spacecraft experiments in their subject area. Working knowledge of FORTRAN is required. Incumbents will serve as acquisition agents for data archived at NSSDC, interface with investigators, and engage in data synthesis efforts, and the generation of data catalogs. Research opportunities available. Send resumes to Dr. H. K. Hills, Sigma Data Services Corp., NASA/GSFC Code 601, Greenbelt, Md. 20771 or call (301) 344-8105.

RESEARCH OPPORTUNITIES

WRAIR · USGS · NWC · NRL · NPS · NORDA · NOAA · NMRDC · NIOSH · NBS · NASA · NADC · MICOM · EPA · DTNSRDC · ASL · ARRADCOM · AFFRI · AFSC

Competitive visiting scholar awards for one or two years' tenure in selected federal laboratories throughout the United States. Opportunities are available for specialized experimental or theoretical research experience—free of interruptions and distractions of other duties—in the general fields of:

ATMOSPHERIC AND EARTH SCIENCES • ENGINEERING LIFE AND MEDICAL SCIENCES PHYSICS • CHEMISTRY ENVIRONMENTAL SCIENCES MATHEMATICS • SPACE SCIENCES

Most of the 19 programs are open to U.S. and non-U.S. nationals, and most are open to experienced senior investigators as well as to recent PhDs.

Application materials with details on research opportunities and laboratory locations may be requested by letter, stating the specific area of research interest, to:

Associateship Programs
(JH 608-U2)
NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue
Washington, D.C. 20418

National Research Council
National Academy of Sciences
National Academy of Engineering · Institute of Medicine

The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to scholarly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

Trent University/Environmental and Resource Studies Program. The Trent Aquatic Research Group invites applications for a Research Associate with interest in movement of radioactive isotopes through aquatic ecosystems. Previous experience in lab and field research in low level isotope measurement or chemical speciation is required. Applicants should possess a Ph.D. in Applied Limnology, Chemical Engineering or equivalent. The position will commence on November 1, 1983. Send a letter of application with C.V. and copies of published papers to: Dr. R. D. Evans, Environmental Center, Trent University, Peterborough, Ontario, Canada.

Chairperson, Department of Geosciences/Texas Tech University. Applications and nominations are sought for the above position. Requirements are a doctoral degree in a suitable specialization within the geosciences, or equivalent experience, and a record that would warrant faculty appointment at the level of Associate Professor or Professor. Desired qualifications are an established record of scientific contributions including a productive current research program, experience in graduate and undergraduate teaching and in supervision of M.S. and Ph.D. students, proven ability to obtain external funding, and indication of strong administrative ability.

Texas Tech University is located in Lubbock, an urban community with a population of over 180,000. The University presently enrolls more than 23,000 students. The Department of Geosciences offers courses in atmospheric science, geochemistry, geology and geophysics. Degree programs include the B.A., B.S., M.S. and Ph.D. in geoscience, and M.S. in atmospheric science. The Department presently consists of approximately 250 undergraduate majors, and 16 faculty.

The position will be available August 1, 1984. The area of specialization is open, faculty rank and salary will be commensurate with qualifications. Applications and nominations should be sent to:

Chairperson Search Committee
Department of Geosciences
Texas Tech University
P.O. Box 4109
Lubbock, Texas 79409

Letters of application should include vita and names and addresses of 5 references. The closing date for applications is January 20, 1984.

Texas Tech University is an equal employment opportunity and affirmative action employer.

Geophysicist Tenure-Track Appointment/Department of Geology, University of Toledo. The position is effective September 1, 1984. Individuals with strong backgrounds in exploration geophysics—applied geophysics are of primary interest although other specializations will be considered. The Ph.D. is required as well as a strong commitment to effective teaching and research. The department has modern facilities and offers B.S., B.A., and M.S. degrees to approximately 60 undergraduate and 30 graduate students. The faculty consists of eight full time and five adjunct professors actively involved in a wide range of research pursuits. Interested persons should submit a letter of application, resume, transcripts, and three letters of recommendation to: Stuart L. Dean, Chairman of Search Committee, Department of Geology, University of Toledo, Toledo, Ohio 43606, phone (419) 537-2246 or (419) 537-2009.

University of Toledo is an equal opportunity/affirmative action employer.

Professor of Marine Geophysics Tectonics/Stanford University. The Department of Geophysics is seeking candidates for a tenure track position in the broad area of marine geophysics and tectonics. We seek a creative scientist with experience in gathering, interpreting, and synthesizing marine geophysical data and whose research interests cover depositional, igneous, and tectonic processes on oceanic plates and continental margins. Inquiries are invited from marine geophysicists with demonstrated scientific record in one of the above aspects of marine geophysics or tectonics, who have demonstrated an ability to develop new ideas and research directions, and to guide and teach graduate and undergraduate students. In considering this appointment we are interested in maximizing interactions with ongoing research groups in marine geology, plate tectonics, paleomagnetism, seismology and regional geology at Stanford. Our new faculty member will be expected to develop a strong research program involving both government and industrial participation.

Salary and rank will be commensurate with experience and background. Please submit a resume, a brief description of teaching and research interests, and references to:

Dr. Amos Nur
Department of Geophysics
321 Mitchell Building
Stanford University
Stanford, CA 94305

Stanford University is an equal opportunity employer, and encourages the application of qualified women and minorities.

POSITIONS WANTED

Physical Chemistry. Ph.D. specialized in Isotopic Geochemical Basic Research would consider challenging opportunity. P.O. Box 018 American Geophysical Union, 2000 Florida Avenue, N.W., Washington, DC 20009.

STUDENT OPPORTUNITIES

GRADUATE STUDENT
NASA TRAINEESHIPS

The Florida State University is accepting applications from prospective graduate students for participation in its NASA sponsored Traineeship Program in Oceanographic Remote Sensing Techniques and Physics of Air-Sea Interaction. The stipend for the calendar year is $10,000. Students may be enrolled for a degree in either oceanography or meteorology. For further information or application, please write:

Dr. James J. O'Brien
NASA Traineeship Program
Meteorology Annex
The Florida State University
Tallahassee, Florida 32306
(904) 644-4581

Meetings

Announcements

River Basins

The International Water Resources Association (IWRA) will hold a seminar at Linköping University in Sweden June 4–8, 1984, to discuss the relevance of the river basin approach to land and water management. The seminar will try to reach conclusions about plans for future actions using the river basin as the basic unit, specifically with regard to the criteria for environmental planning, for conflict resolution, and for developing coordinated land and water control.

Papers will deal with eight selected river basins and with four issues: river basins as ecosystems; legal and administrative issues; the problems of growing urban systems; and the problems of coordinating control and management of land and water resources.

Those interested in attending should contact Ulrik Lohm, Water Theme, Linköping University, S-58183, Linköping, Sweden.

Offshore Minerals

A symposium to discuss plans for assessing and developing mineral resources in the recently proclaimed Exclusive Economic Zone off the coast of the United States will be held November 15–17 at the U.S. Geological Survey (USGS) National Center in Reston, Va. The symposium is being sponsored by the USGS, the Minerals Management Service, and the Bureau of Mines to aid in organizing a coordinated government, university, and industry effort to evaluate the potential mineral resources in the new zone; the zone was proclaimed on March 10, 1983, to extend U.S. mineral rights 200 miles offshore.

Presentations on current federal marine mineral resource activities will be followed by panel discussions on the science of resource assessment, the engineering technology involved, and the legal ramifications in developing these offshore minerals. The Secretary of the Interior is scheduled to be the keynote speaker; others from the White House, Congress, Department of Commerce, Navy, industry, and academia also will speak.

For additional information, contact the Assistant Secretary, Energy and Minerals, Department of the Interior, Washington, DC 20240 (telephone: 202-343-5691).

AGU Fall Meeting: Travel, Housing, Registration

The 1983 Fall Meeting of the American Geophysical Union will be held in San Francisco, Calif., December 5–9, at the Cathedral Hill Hotel and the Holiday Inn Golden Gateway Hotel. San Francisco is a dynamic, exciting city, known to the world for its spectacular scenery, fabulous restaurants, cosmopolitan life style, and gentle climate. It is a superb meeting location at any time of the year.

Registration

Everyone who attends the meeting must register. Preregistration (received by November 10) saves you time and money. The fee will be refunded to you if AGU receives written notice of cancelation by November 28. Registration rates are as follows:

	Preregistration	After Nov. 10
Member	$65	$80
Student member	$32	$47
Retired senior member (65 or over)	$32	$47
Nonmember	$90	$105
Student nonmember	$41.50	$56.50

Registration for 1 day only is available at one half the above rates, either in advance or at the meeting. Members of the American Congress on Surveying and Mapping, the American Meteorological Society, the American Society of Photogrammetry, the European Geophysical Union, and the Union Geofísica Mexicana may register at the AGU member rates.

If you register as a nonmember for more than 1 day, the first-year dues for joining AGU will be waived if a completed application is received at AGU by Feb. 10, 1984.

To preregister, fill out the registration form, and return it with your payment to AGU by November 10. Your receipt will be included with your preregistration material at the meeting. Preregistrants should pick up their registration material at the registration desk at the Cathedral Hill Hotel. Hours are 8 A.M. to 4 P.M., Monday through Friday. On Sunday, December 4, registration hours are 5:30 to 7:30 P.M.

Hotel Accommodations

Blocks of rooms ($47 single, $53 double) are being held at the Cathedral Hill, the Holiday Inn Golden Gateway, the Holiday Inn Civic Center, the San Franciscan, and the Grosvenor Inn for those attending. Read the housing application, and mail the completed application form to the housing bureau early to ensure reservations at your preferred hotel. *Reservation forms must be sent directly to the Housing Coordinator, AGU Fall Meeting, San Francisco Housing Bureau, P.O. Box 5612, San Francisco, CA 94101.* Do not send housing reservation forms to the hotels.

Reservations must be received by November 1 to be confirmed. Do not write or call AGU for room reservations.

Free parking is available only to registered guests of each hotel as indicated.

Scientific Sessions

The program summary appears later in this issue. The preliminary program and the abstracts will be published in *Eos*, November 8. The final program, with presentation times, will be distributed at the meeting. Both the Cathedral Hill and the Holiday Inn Golden Gateway hotels will be used for all disciplines.

Poster Sessions Poster sessions will be held throughout the meeting in the Eldorado Room at the Cathedral Hill Hotel. Check the program for detailed scheduling. AGU will provide each poster-session presenter with a mounting area measuring 4 x 6 feet (1.25 x 2 m). Plan your exhibit to fit this space. The board will be assigned by number corresponding to the presenter's abstract number. The boards will be set up in the Eldorado Room before the poster session begins. Thumb tacks, push pins, tape, and scissors will be available in the meeting room.

Exhibits

The exhibits will be located on the Mezzanine, Cathedral Hill Hotel, Monday, December 5, through Thursday, December 8, 9:30 A.M. to 4:00 P.M.

The following exhibitors are confirmed:

Academic Press, Inc.
American Geophysical Union
Defense Mapping Agency/HTC
Digital Imaging Processing
EG&G Geometrics
Elsevier Science Publishing Co.
Handar
Jet Propulsion Laboratory
Kinemetrics
Nature's Own
Phoenix Geophysics
Qualimetrics, Inc.— WEATHERtronics
Refraction Technology
Schonstedt Instrument Co.
Sprengnether Instruments
Springer-Verlag, New York
Teledyne Geotech
Terra Technology
U.S. Geological Survey

Social Events

An icebreaker party on Monday evening on the Mezzanine at the Cathedral Hill Hotel will be the opening social event of the meeting. To honor John W. Handin, the 1983 recipient of the Bucher Medal, and those 1983 AGU Fellows who were not present at the 1983 Spring Meeting, there will be an awards ceremony and wine tasting reception on Thursday evening, 6:00–7:30 P.M., in the

Meetings *(cont. on p. 602)*

RETURN THIS FORM WITH PAYMENT TO:

Meeting Registration
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

PLEASE PRINT CLEARLY

NAME ON BADGE ____________________

AFFILIATION ____________________

MAILING ADDRESS ____________________

TELEPHONE # ____________________

HOTEL ____________________

Days you plan to attend
Please check the appropriate box(es)
☐ Dec. 5 ☐ Dec. 6 ☐ Dec. 7
☐ Dec. 8 ☐ Dec. 9

Please check appropriate box
☐ Member AGU ☐ Nonmember

Members of the cooperating societies may register at AGU member rates

Member cooperating society:
☐ AMS-American Meteorological Society
☐ ASP-American Society of Photogrammetry
☐ ACSM-American Congress on Surveying and Mapping
☐ EGU-European Geophysical Union
☐ UGM-Union Geofisica Mexicana

Nonmembers

If you register as a nonmember for more than 1 day, the first-year dues for joining AGU will be waived if a completed application is received at AGU by Feb. 10, 1984.

Preregistrants

Your receipt will be in your preregistration packet. The registration fee will be refunded if written notice of cancelation is received in the AGU office by November 28. The program and meeting abstracts will appear in the November 8 issue of *Eos*.

AGU 1983 FALL MEETING
DECEMBER 5-9
San Francisco, California

REGISTRATION FORM

Deadline for Receipt of Preregistration
NOVEMBER 10, 1983

(rates applicable only if received by November 10 with payment)

	More than one day	One day
MEMBER	☐ $65	☐ $32.50
STUDENT MEMBER	☐ $32	☐ $16
RETIRED SENIOR MEMBER*	☐ $32	☐ $16
NONMEMBER	☐ $90	☐ $45
STUDENT NONMEMBER	☐ $41.50	☐ $20.75

*65 or over

SECTION LUNCHEONS/DINNER

Circle section and indicate number of tickets. All lunches begin at noon. SPR dinner begins at 6:30 P.M.

____ Planetology/Volcanology, Geochemistry and Petrology, Tuesday, $9
____ Seismology/Tectonophysics, Tuesday, $5
____ Geomagnetism and Paleomagnetism, Wednesday, $5
____ Hydrology, Wednesday, $9
____ Ocean Sciences, Wednesday, $9
____ Solar-Planetary Relationships, Wednesday, $20 (dinner)
____ Atmospheric Sciences, Thursday, $9
____ Geodesy, Thursday, $9

Total Enclosed $ ____________
(All orders must be accompanied by payment or credit card information. Make check payable to AGU.)

Charge to: ☐ American Express ☐ Visa ☐ Master Card

Card Number ____________

Master Card Interbank No. ____________

Expiration Date ____________

Signature ____________

Office Use

Code

Check

FIELD TRIP FORM

I wish to attend the Francisca Nuno-terrane field trip on Sunday, December 4. My check for $25 is enclosed.

In case I am not among the first 40:

☐ I wish to be put on the waiting list. (If you don't go, money will be returned on the day of the trip.)

☐ I wish my money returned.

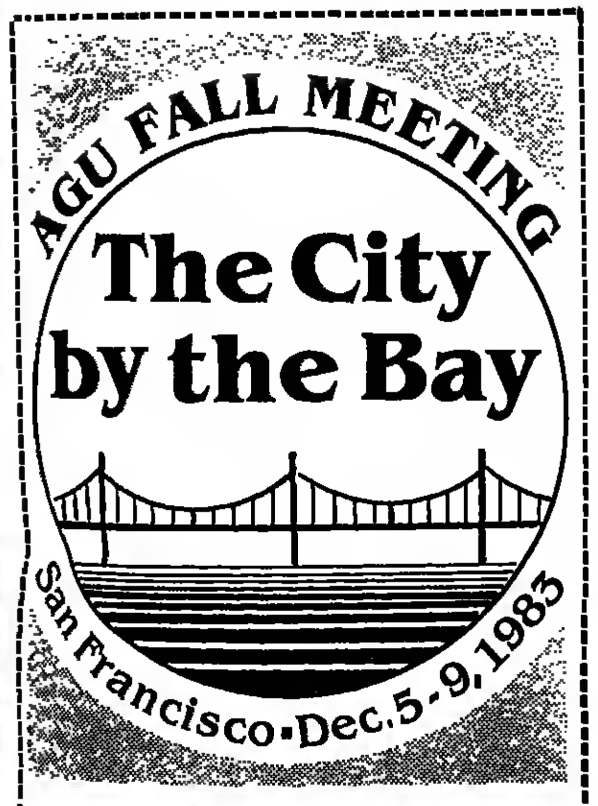
Signature ____________ Print Name ____________

Date ____________

Address ____________

Telephone ____________

Mail form to: M. C. Blake, Jr., Mail Stop 75, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025



HOTEL ACCOMMODATIONS

PARTICIPATING HOTELS

Cathedral Hill Hotel
Van Ness at Geary Street
(800) 227-4730

Holiday Inn Golden Gateway
1500 Van Ness Avenue
(415) 441-4000

Grosvenor Inn
Van Ness and Geary
(415) 673-7411

Holiday Inn Civic Center
50 8th Street
(415) 626-6103

San Franciscan Hotel
1231 Market Street
(415) 626-8000

ROOM RATES FOR ALL HOTELS

Single $47
Double $53
Twin $53

Suites available upon request

PARKING: Cathedral Hill Hotel: free to registered guest
Holiday Inn Golden Gateway: free to registered guest
San Franciscan Hotel: free to registered guest

All hotel reservations must be made on the housing form by November 1, 1983. No telephone requests will be accepted. Confirmations will be mailed directly to registrants by the individual hotels. After confirmation has been received, changes and cancelations should be made directly to the hotel.

Mail your completed form directly to:

Housing Coordinator
AGU Fall Meeting
San Francisco Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

American Geophysical Union

1983 FALL MEETING

HOUSING REGISTRATION FORM

READ CAREFULLY and RETURN FORM DIRECTLY TO THE SAN FRANCISCO HOUSING BUREAU AT THE FOLLOWING ADDRESS:

Housing Coordinator
AGU Fall Meeting
SF Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

Please print or type all information, abbreviating as necessary. Confirmation will be sent by the hotel to the individual named in Part I. If more than one room is required, this form may be photocopied.

Part I

REQUESTOR

Last Name First

Name of Company or Firm

Street Address or P.O. Box Number

City State/Prov. Zip-U.S.A.

Country Telephone Number

Part II

INSTRUCTIONS: Select *THREE* hotels of your choice from the list of participating facilities, then enter the name on the lines below.

First Choice ____________ Second Choice ____________ Third Choice ____________

NOTE: Rooms are assigned on a "First Come, First Served" order, and if none of your choices is available, another facility will be assigned based on a referral system. A cut-off date is in effect; your application may not be processed if received after 14 days prior to your arrival date. **AGU housing registration deadline is November 1.**

Part III

INSTRUCTIONS: 1. Select type of room desired with arrival and departure dates.
2. *PRINT* or *TYPE* names of *ALL* persons occupying room.
3. If more than two persons share a room, check twin and the hotel will assign two double beds.

CHECK ONE		Guest Names (Last name first)
☐ SINGLE (Room with one bed one person)	Arrival Date ____	1. ____
☐ DOUBLE (Room with one bed two persons)	Arrival Time ____ AM/PM	2. ____
☐ TWIN (Room with two beds two persons)	Departure Time ____	3. ____
☐ EXTRA PERSON		4. ____

IMPORTANT NOTE: Hotel MAY require a deposit or some other form of guaranteed arrival. If so, instructions will be on your confirmation form.

Meetings (cont. from p. 601)

Emerald Ballroom of the Holiday Inn Golden Gateway. All meeting participants are invited to attend.

Complimentary refreshments will be served daily, at both hotels, 9:15–11:00 A.M. and 2:15–4:00 P.M.

Business Meetings and Section Luncheons/Dinner

The AGU Council will meet Tuesday, December 6, at 5:30 P.M., in the Japanese Pavilion Room, Cathedral Hill Hotel.

The section lunches and dinner will be held at the following restaurants: Nikko, at Van Ness and Pine; Casa de Cristal, 1122 Post Street; A. Sabella's, on Fisherman's Wharf; and the Holiday Inn Golden Gateway. Purchase your ticket now as space is limited.

Tuesday, December 6

- Planetology and Volcanology, Geochemistry, and Petrology. Noon, Casa de Cristal, $9.
- Seismology and Tectonophysics. Noon, Nikko, $5. Sponsors, Kinemetrics, Inc., Teledyne Industries, Inc., W. F. Sprengnether Instrument Co., Inc.

Wednesday, December 7

- Geomagnetism and Paleomagnetism. Noon, Casa de Cristal, $5. Sponsors, Schonstedt Instrument Company, CFT Systems.
- Hydrology. Noon, Holiday Inn Golden Gateway, $9.
- Ocean Sciences. Noon, Nikko, $11. Program: Gordon Hamilton, Office of Naval Research, will speak on "ONR's Environmental Science Program."
- Solar-Planetary Relationships, business meeting, with dinner to follow, at A. Sabella's Restaurant. 5:15 P.M., business meeting, Emerald Room, Holiday Inn Golden Gateway; 6:45 P.M., dinner, A. Sabella's, $18.50 (Italian gourmet).

Thursday, December 8

- Atmospheric Sciences. Noon, Nikko, $9.
- Geodesy. Noon, Holiday Inn Golden Gateway, $5. Sponsor, Bell Aerospace Textron.

Field Trip

On Sunday, December 4, 9 A.M. to 5 P.M., in connection with the Nano-Plate-Tectonic Symposium, there will be a field trip to the Franciscan nano-terranes in San Francisco, stressing their contact relations. The trip will be led by Clark Blake and Clyde Wahrhaftig. The $25 per-person cost includes tour bus, lunch, and field trip guide.

The trip, which will leave from and return to the Cathedral Hill Hotel, will be limited to 40 persons, and space will be reserved for the first 40 to sign up. Others can be put on a waiting list, or their checks can be returned, as they wish. Those interested should send the form printed in this issue with a check made out to M. C. Blake, Jr., addressed as indicated on the form. Be sure to mark on outside of the envelope "For AGU Dec. Field Trip."

Program Summary

Union
Orinoco & Amazon, Tues AM
Computers & Geosciences, Tues PM
Nuclear Consequences, Wed AM
Polar Research, Thurs AM

Atmospheric Sciences
Lightning, Mon PM
Thunderstorms, Tues AM
CCOPE, Tues PM
Effects of Nucl. Bursts, Wed PM
Troposph. Chemistry I, Thurs PM
Troposph. Chemistry II, Fri AM
Climate & Chemistry, Fri PM

Geodesy
LAGEOS I, Mon AM
LAGEOS II, Mon PM
Earth Rot./Orient., Tues AM
Oceans/Geodesy/Tect., Wed PM
Crustal Dynamics I, Thurs AM
Crustal Dynamics II, Thurs PM
GPS & Gravity, Fri AM

Geomagnetism & Paleomagnetism
Theory & Anisotropy, Mon AM
Recognizing Alteration, Mon PM
Sec. Variat., Excursion, Tues AM
Calif., Baja to Sur, Tues PM
Oregon to Alaska, Wed AM
Paleopoles & APW Curves, Wed PM
Statistics & Sampling, Thurs AM
Melts & Conduct. Paths, Thurs PM
Magnetotell. Variat., Fri AM

Hydrology
Glacier/Ocean Interact., Mon AM
Streamwater Geochem., Mon PM
Orinoco & Amazon I, Tues PM
Geo. Hydrol. Poster Sess., Tues PM
Orinoco & Amazon II, Wed AM
Instream Flow, Wed AM
General Groundwater I, Wed AM
Sediment Transport I, Wed AM
Geo. Hydrol./Stochastic, Wed PM
Sediment Transport II, Wed PM
Multivariate Models I, Thurs AM
Groundwater Optimization, Thurs AM
Multivariate Models II, Thurs PM
General Hydrology, Thurs PM
Watershed Models, Fri AM
Floods I, Fri AM
General Groundwater II, Fri PM
Floods II, Fri PM

Oceanography
Geochemistry of Estuaries, Mon AM
CODE/OPUS/SUPER-CODE, Mon AM
El Niño, '82-'83, Mon PM
MANOP, Mon PM
Hydrothermal Vents, Tues AM
Calif. El Niño, '82-'83, Tues AM
Coastal Oceanography, Tues PM
Seabed Morphology, Wed AM
Physical Oceanography, Wed AM
Diagenesis in DSDP, Wed PM
Marine Chemistry, Thurs AM
General Circulation, Thurs PM
Paleoceanography, Fri AM
Response to Strong Wind, Fri AM
Sub-seabed Disposal, Fri PM
Marginal Seas, Fri PM

Planetology
Surfaces & Atmospheres, Wed PM
Satellites & Cratering, Thurs PM

Seismology
Coalinga Earthquake, Mon AM
Mostly Nuclear, Mon AM
Rio Grande Rift, Mon PM
Lateral Heterogeneity, Mon PM
Oceanic Lithosphere I, Tues AM
Earthquake Chemistry, Tues AM
Oceanic Lithosphere II, Tues PM
Earthquake Hydrology, Tues PM
Earthquake Prediction, Tues PM
Crust & Upper Mantle I, Wed AM
Crust & Upper Mantle II, Wed PM
Marine Seismology, Wed PM
Sources & Strong Motion, Wed PM
Future Global Network, Wed PM
Seismicity & Tectonics I, Thurs AM
Wave Propagation I, Thurs AM
Seismicity & Tectonics II, Thurs PM
Wave Propagation II, Thurs PM
Long Period Seismology, Fri AM
Tomography/Networks, Fri PM

SPR: Aeronomy
Ionosphere: Radar, Mon PM
Ionosphere, Tues AM
Airglow-Aurora Poster, Tues AM
Middle Atmosphere, Tues PM
Mesosph.-Thermosph. I, Wed AM
Mesosph.-Thermosph. II, Wed PM
Mesosph.-Thermosph. III, Thurs AM
Airglow, Thurs PM
Euv-Airglow I, Fri AM
Euv-Airglow II, Fri PM

SPR: Cosmic Rays
Cosmic Rays, Mon AM
IMP 7 & 8, Mon PM
IMP 7 & 8, Tues AM

SPR: Magnetospheric Physics
Aurora/Substorms I, Mon AM
AMPTE Program I, Mon AM
Jupiter/Saturn, Mon AM
Aurora/Substorms II, Mon PM
AMPTE Program II, Mon PM
Reconnection, Tues AM
Aurora/Substorms III, Tues AM
Electric Currents/Fields, Tues AM
Compar Planet Msph I, Tues PM
Compar Planet Msph II, Wed AM
VLF Waves, Wed AM
History of VLF Research, Wed PM
Spacecraft Effects I, Wed PM
Ion Composition/Dynamics, Thurs AM
Spacecraft Effects II, Thurs AM
Magnetic Pulsations I, Thurs AM
Charged Particles I, Thurs PM
Waves/Instabilities I, Thurs PM
ISEE-3 in Magnetotail I, Fri AM
Waves/Instabilities II, Fri AM
Auroral Hiss & AKR, Fri AM
Magnetic Pulsations II, Fri AM
Charged Particles II, Fri AM
ISEE-3 in Magnetotail II, Fri PM
Magnetospheric Tail, Fri PM
Ionospheric Radars, Fri PM
Waves/Instabilities III, Fri PM

SPR: Solar & Interplanetary Physics
Solar Phenomena, Tues AM
Solar Wind, Tues PM
Shocks/Upstream Phenomena, Wed AM
Solar Physics, Wed PM
Solar Wind Int. w/ Comets, Thurs AM
S.W. Int. w/ Venus/Titan, Thurs PM

Tectonophysics
Tect. Sed. Active Marg. I, Mon AM
Fault Zone Drilling I, Mon AM
Marine Tectonics, Mon AM
Tect. Sed. Active Marg. II, Mon PM
Fault Zone Drilling II, Mon PM
Heat Flow, Mon PM
Mantle/Crustal Dynamics, Tues AM
Deformation, Tues AM
Tectonic Hazards, Tues PM
Tectonics: General, Tues PM
Recent Trends, Wed AM
Active Margins, Wed AM
High Pressure Research, Wed AM
Physics of Magma Transfer, Wed PM
Fracture & Faulting, Wed PM
Rift Research, Wed PM
Active Tectonics I, Thurs AM
East Pacific Rise, Thurs AM
Tectonics Poster Session, Thurs AM
Active Tectonics II, Thurs PM
Himalayan-Alpine, Thurs PM
Tectonophys. Poster Sess., Thurs PM
Salton Sea Drilling, Fri AM
California Tectonics, Fri AM
Circum-Pac. Tectonics: SE, Fri AM
Franciscan Geology SF Bay, Fri PM
Phys., Chemistry Minerals, Fri PM
Circum-Pac. Tectonics: N, Fri PM
Circum-Pac. Tectonics: SW, Fri PM

Volcanology, Geochemistry, & Petrology
Calderas I, Mon AM
Mineral Physics I, Mon AM
Calderas II, Mon PM
Metamorphism, Mon PM
Calderas III, Tues AM
Gases, Tues AM
Calderas IV, Tues PM
Ore Deposits, Tues PM
Cascades I, Wed AM
Laki Bicentennial, Wed AM
Calderas V, Wed PM
Arc Volcanism, Wed PM
Cascades II, Thurs AM
VGP Potpourri, Thurs PM
Cascades III, Thurs PM
Hawaii I, Fri AM
Mantle Petrology, Fri AM
Hawaii II, Fri PM
Isotopic Studies, Fri PM

Air Fare Information

Special AGU Discounted Air Fares Available When You Fly UNITED to San Francisco

Your toll-free number for flight reservations: 800-521-4041 (Michigan residents 800-482-0243)

Your AGU Convention Number 4367

Special arrangements have been made with United Airlines to offer you a $10 discount off Super Saver fares with the 7-day minimum stay requirements waived . . . only available when you call the unlisted, toll-free number of United's Convention Desk: 8:30 A.M.–5:30 P.M. EST, Monday–Friday.

Just call the above number, available to those within the 48 contiguous states. Ask for the Convention Desk. Tell them you are attending the AGU convention in San Francisco or give them AGU's convention number: 4367.

Here are the details on your special AGU convention fare:

- $10 discount on the roundtrip Super Saver/coach fare in effect at the time of travel.
- The 7-day minimum stay is NOT required.
- Travel must commence no earlier than December 1, 1983, and must be completed on or before December 12, 1983.
- Reservations should be made as early as possible. The final date for reservations and ticketing is the day before departure. Reservations will be accepted after this date, but at the higher fare.
- Ticket purchase may be made directly from United; they will mail your tickets direct to you. Just provide your form of payment when you call. If you wish to purchase your ticket through an authorized travel agency, you may do so. However, YOU, not your travel agent, should call United's unlisted number.

Special Note

In the current "air fare war" there may be sporadic and short-lived discounted fares from specific cities to San Francisco. These fares have restrictions and are limited. United's convention specialists will assist you in determining if your travel plans meet these specific restrictions.

AGU and United Airlines are working together to bring you a better meeting for less. Use the United Convention Desk; help yourself and AGU at the same time.

Chapman Conference on Collisionless Shock Waves in the Heliosphere

February 20–24, 1984
Silverado Country Club and Resort
Napa Valley, California

Convenor: R. G. Stone

Abstract Deadline: November 22, 1983

Invited reviews and contributed papers in the following general areas: Overview of the collisionless shock, macroscopic aspects of shocks, microscopic aspects of shocks and particle acceleration. Typical subjects to be covered include:

- Why and where shocks form in the heliosphere?
- Shock dynamics and evolution.
- Shocks associated with solar activity, planetary bow shocks, corotation shocks, and shock-shock interactions.
- Subcritical, supercritical, quasi-parallel, and quasi-perpendicular shocks.
- Dissipation mechanisms.
- The foreshock.
- Particle acceleration mechanisms.

Student Travel Assistance: Deadline November 30. Student travel funds are available. To apply, write to Shock Waves Meeting, AGU, giving your educational background and your research interests.

Publication: A proposal for the publication of the invited papers as a monograph is under consideration by the AGU Monograph Board. It has also been recommended that the contributed papers be published as a separate monograph or be submitted to JGR-Space Physics through the normal AGU peer review process.

Contact: AGU Meetings, 2000 Florida Avenue, N.W., Washington, DC 20009
toll free: (800) 424-2488 D.C. area 462-6903

Call for papers published in EOS, May 31, 1983

Awards Ceremony and Reception

Thursday, December 8
6:00 - 7:30 p.m.
Emerald Ballroom, Holiday Inn

To honor John W. Handin, the 1983 recipient of the Bucher Medal, and those 1983 AGU Fellows who were not present at the Spring Meeting there will be an awards ceremony and wine-tasting reception. All meeting participants are invited and urged to attend.

AGU

Section Candidates

Eos is carrying biographies and photographs of all candidates for President-elect, General Secretary, and Foreign Secretary of the Union and for President-elect and Secretary of each Section. In addition, statements by the candidates for Union offices and for Section President-elect will appear. Candidates for the Seismology Section and an additional candidate for the Planetology Section appear below. The material for the sections of Geodesy, Geomagnetism and Paleomagnetism, and Planetology appeared in the August 30 issue; for the Atmospheric Sciences Section in the September 27 issue; and for the Tectonophysics Section in the October 11 issue. The slate of candidates for all offices was carried in the June 21 issue.

Seismology: President-elect

F. A. Dahlen A member of AGU since 1968; 40 years old. Professor of Geophysics, Princeton University. Major interests: theoretical seismology and mechanics, free oscillations, rotation of the earth. B.S. in geophysics, Caltech, 1964; Ph.D. in geophysics, UCSD, 1969. At Princeton since 1970. Member AGU, SSA, RAS. On editorial board of *The Geophysical Journal* 1977–1979; NSF Earth Sciences Panel 1982–83; 39 publications, 6 in AGU journals. Alfred P. Sloan Foundation Fellow 1971–1973. Candidate Stewart W. Smith (see below) taught Dahlen's first course in geophysics and provided his first summer job in geophysics.

Statement

"The Seismology Section of AGU is currently in very capable and distinguished hands, and I do not envision initiating any major shifts in policy if elected. I would use the 2-year term as President-elect to become better informed about the affairs of the Section and the Council, by soliciting the views and advice of the membership and the present and past officers of the Section. The principal function of AGU is to foster scientific communication through its program of meetings, conferences, and journals. I would be opposed to any significant change in format of the annual meetings despite the obvious problems caused by increasing attendance, because they provide such a valuable forum for students and others entering the field to discuss their work and meet their peers and colleagues. The AGU journals are healthy and highly respected, and it is important they remain so. Submission of papers in electronically encoded form, an option recently adopted by the journals of the APS, should be investigated. This would be particularly valuable for heavily mathematical articles requiring careful proofreading."

Stewart W. Smith A member of AGU since 1959; 50 years old. Professor of Geophysics, University of Washington. Major interests: seismicity, tectonics, and crustal deformation. S.B. in geology, MIT, 1954; Ph.D. in geophysics, Caltech, 1961. Geophysicist, Shell Oil Company, 1954–1957; Assistant and Associate Professor, Caltech, 1961–1970; Professor and Chairman of Geophysics, University of Washington, 1970–1980. Member SSA, EERI, SEG. Has been chairman, Geophysics Advisory Panel AFOSR, Director of SSA, on editorial committee of *Annual Review of Earth and Planetary Sciences*, on Seismology Committee on NAS/NRC, and served on advisory committees and panels for USGS, USNRC, EERI, IASPEI, and NSF; 41 publications, 11 published by AGU. Served as Program Chairman for AGU Seismology Section.

Statement

"The primary objective of AGU, and our Section in particular, is to provide communication within the scientific community and to the general public. I view the most important function of AGU officers to be the review and evaluation of the mechanisms by which we achieve this communication to determine if they are meeting our needs. Beyond the journals, newsletter, symposia, and general meetings, we need to be prepared to utilize the new tools that technology can provide to store, catalog, and transmit information. Ultimately the progress of our field will depend on how effectively we can learn from each other. I would hope that AGU will be at the forefront in the application of the next generation of communications and knowledge based systems to achieve this result."

Seismology: Secretary

William L. Ellsworth A member of AGU since 1972; 34 years old. Chief, Branch of Seismology, U.S. Geological Survey, Menlo Park, Calif. Major interests: earthquake seismology and lithospheric structure. B.S. in physics and M.S. in geophysics, Stanford University, 1971; Ph.D. in geophysics, MIT, 1978. U.S. Geological Survey since 1971. Member AGU, SSA, SEG, Sigma Xi, and JMGS. Member of Panel on Seismological Studies of the Continental Lithosphere of NAS/NRC; served on advisory panels for U.S. Nuclear Regulatory Commission and Committee on Seismology, NRC; 17 publications, 7 published by AGU.

Emile A. Okal A member of AGU since 1974; 33 years old. Associate Professor of Geology & Geophysics, Yale University (as of January 1, 1984: Associate Professor of Geological Sciences, Northwestern University). Major interests: seismology, plate tectonics, intraplate volcanism, marine geophysics. M.S., Ecole Normale Supérieure and University of Paris, 1972; Ph.D. in geophysics, Caltech, 1978. Came to U.S. in 1974; naturalized in 1982. Faculty member at Yale since 1978; will move to Northwestern January 1. Member: AGU, SSA. About 40 publications, 7 in AGU journals. Associate Editor, JGR-Red, 1983–1985; Program Chairman for Seismology, AGU Spring Meeting, 1983 and 1984.

Planetology Petition Candidate: Secretary

Gregory F. Herzog has been approved as an additional candidate for Secretary of the Planetology Section.

Gregory F. Herzog A member of AGU since 1971; 39 years old. Associate Professor, Department of Chemistry, Associate member, Graduate Program, Department of Geology, Rutgers University. Major interests, meteorities. B.A., 1964, Cornell University; M.A., 1965, Ph.D., 1970, Columbia University; Resident Associate, University of Chicago, 1969–1971. Since 1971, Department of Chemistry, Rutgers University. 1976–1977 Max-Planck-Institut für Kernphysik, Heidelberg. Member AGU, AAAS, Meteoritical Society. XRF User Subgroup Representative, National Sync. Light Source. Associate Editor, 12th Lunar and Planetary Science Conference. 32 publications, 8 published by AGU.

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Paul Michael Abrahaon (S), Gusngfen Cheng (O), Donald Galys (O), Jeremy R. Henderson (S), Peter Hufschmied (H), Dieter M. Imboden (O), David R. Jones (V), Stephen Lane (S), W. G. Large (O), Denis Lefaivre (O).

Student Status

Debao Bai (A), Cecilia Binig (T), Richard A. Degner (S), Hjalmar Eysteinsson (GP), John R. Farver (V), Vanessa L. Griffin (M), Eugene O. Humphreys (S), Eugene S. Ilton (V), Richard A. Iverson (H), Carlos Krepper (O).

THE TWO CAREER COUPLE

Balancing Personal and Professional Life

AGU Fall Meeting
Wednesday, December 7
5:45 - 7:30 p.m.
Pacific Heights-Presidio
Cathedral Hill Hotel

Connie Sanchetta will moderate a discussion of the problems couples face when both are active and recognized in their professional fields. Panelists will include Mark and Mary Lou Zoback (U.S.G.S.), Alice Newman (The Aerospace Corporation), and Thomas Worsley (Ohio University).

This program has been arranged by the AGU Education and Human Resources Committee. Refreshments will be available.

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU. *Cost:* $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order. Deposit accounts available.

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Electromagnetics

0770 Radio Oceanography
ATTENUATION RATES OF COASTAL RADAR SIGNALS AT 25 MHZ
R.B. Lyons (Wave Propagation Laboratory, NOAA/ERL, Boulder, Colorado 80303), D.E. Barrick (Ocean Surface Research, Boulder, Colorado 80303)
The attenuation rate of the ground-wave signal with range is a factor limiting the performance of coastal HF radars (CODARs). We show that observed attenuation rates are less than theoretically predicted rates at 25 MHz. This result, contrary to earlier findings at lower frequencies, suggests the onset of tropospheric ducting above 20 MHz. The attenuation rates for various sea states and distances are tabulated to allow estimates of system performance near 25 MHz. (Ground-wave attenuation, radar propagation)
Rad. Sci., Paper 3S1557

0773 Remote Sensing
DIFFERENTIAL REFLECTIVITY AND CIRCULAR POLARIZATION RADAR SIGNALS AND RELATED DROP OSCILLATION AND PROPAGATION EFFECTS IN RAINFALL
T. A. Seliga (Atmospheric Sciences Program and Department of Electrical Engineering, Ohio State University, Columbus, Ohio 43210), K. Aydin and V. N. Bringi
Differential reflectivity (Z_{DR}) and circular depolarization ratio (CDR) radar signals are directly related to each other and to the median drop size diameter of rainfall when the drop sizes are exponentially distributed. These polarization parameters are examined for both static and oscillating raindrop shapes along with their relationships with rainfall rate and liquid water content estimates derived from Z_{DR} or CDR and reflectivity factor (Z) measurements. Propagation effects at S band wavelengths are also considered and shown to be particularly important in CDR measurements. (Differential reflectivity, radar meteorology, aircraft particle measurements, graupel).
Rad. Sci., Paper 3S0031

0773 Remote Sensing
ANALYSIS OF AIRCRAFT HYDROMETEOR SPECTRA AND DIFFERENTIAL REFLECTIVITY (Z_{DR}) RADAR MEASUREMENTS DURING THE COOPERATIVE CONVECTIVE PRECIPITATION EXPERIMENT
V. N. Bringi (Department of Electrical Engineering, Colorado State University, Ft. Collins, Colorado 80523), T. A. Seliga and E. A. Cooper
Radar measurements of Z_{DR} are compared with Z_{DR} deduced from aircraft graupel spectra during the Cooperative Convective Precipitation Experiment. On August 4, 1981, the University of Wyoming's Super King Air made two penetrations (at altitudes of 3 km and 1.5 km above mean sea level) through a convective cell located 90 km NE of the CHILL radar. The aircraft was equipped with two two-dimensional PMS probes located orthogonally so as to view the falling hydrometeors along their symmetry axis (V probe) and along an axis orthogonal to it (H probe). Elliptical raindrop images were observed below cloud base (1.8 km altitude), and conical graupel images were observed at 3 km altitude. Because of beam blockage at the lowest elevation scans, radar data were not available in the rain region. Aircraft raindrop spectra were analyzed in detail, and it is shown that Z_{DR} deduced from such spectra should be an excellent estimator of D_0 provided the correct form for the drop size distribution is assumed. Z_{DR} and Z_H deduced from the graupel spectra are shown to be in the range measured by the radar. (Differential reflectivity, radar meteorology, aircraft particle measurements, graupel).
Rad. Sci., Paper 3S0621

0773 Remote Sensing (Multispectral Passive Microwave)
A SUMMARY OF RESULTS FROM THE FIRST NIMBUS-7 SMMR OBSERVATIONS
P. Gloersen (Code 912, Goddard Laboratory for Atmospheric Sciences, Goddard Space Flight Center, Greenbelt, Maryland 20771), D.J. Cavalieri, A.T.C. Chang, T.T. Wilheit, W.J. Campbell, O.M. Johannessen, K.B. Katsaros, K.F. Kunzi, D.B. Ross, D. Staelin, E.P.L. Windsor, F.T. Barath, P. Gudmandsen, E. Langham, and R.O. Ramseier
Selected data obtained during the first year of operation of the Scanning Multichannel Microwave Radiometer (SMMR) on board the Nimbus-7 satellite (launched in late October 1978) have been used to calculate on a global basis various geophysical parameters over open oceans, polar regions, and terrain. Over open oceans, these calculations have provided inferred values for sea surface temperatures, near-surface winds, atmospheric water vapor in a column, and rainfall rates. In polar regions, sea ice concentration, multiyear ice fraction, and radiating temperatures have been obtained. Finally, the extent and water equivalence of snow cover over terrain have been calculated. These retrieved snow parameters have been compared with in-situ measurements of the same geophysical parameters, where available, and the results of these comparisons are described. The self-consistency of the global displays of all the parameters is discussed, along with the plans for archiving them for subsequent research purposes. A description of the SMMR calibration and data processing scheme is also given.
J. Geophys. Res., Green, Paper 3C1503

0780 Scattering
DIFFERENTIAL RADAR SCATTERING PROPERTIES OF MODEL HAIL AND MIXED-PHASE HYDROMETEORS
K. Aydin (Atmospheric Sciences Program and Department of Electrical Engineering, Ohio State University, Columbus, Ohio 43210), T. A. Seliga and V. N. Bringi
The differential reflectivity (Z_{DR}) radar signal contains information on the shape and alignment of ice phase hydrometeors. Under certain circumstances, then, this signal and reflectivity factor can be used to identify the presence of hail particles. Such interpretations require knowledge about the scattering properties of various types and shapes of hydrometeors including ice, water-coated ice, and graupel. These hydrometeors are examined for their differential scattering properties obtained from computations using the transition (T) matrix method of Waterman and an extension of this theory to two-layered bodies. Differential radar cross sections together with circular depolarization ratios are presented, and several instances of possible hail detection by radar using Z_{DR} signatures are illustrated. (Scattering, radar meteorology, hail, differential reflectivity).
Rad. Sci., Paper 3S0819

Exploration Geophysics

0930 Seismic methods
VELOCITY ESTIMATES DERIVED FROM THREE-DIMENSIONAL SEISMIC DATA
Kwame Owusu (Mobil Petroleum Co., One Lincoln Center, 5400 LBJ Freeway, Ste. 1200-LB 25, Dallas, TX 75240) G.H.F. Gardner and Hugh D. Hassell
A new computer algorithm is described by which velocity estimates can be derived from three-dimensional (3-D) multifold seismic data. The velocity estimate, referred to as "imaging velocity," is that which best describes the diffraction hyperboloid due to a scatterer. The scattering center is best imaged when this velocity is used in the reconstruction process.
The method is based on the 3-D Kirchhoff summation migration before stack. The implementation consists of two basic phases: (1) differentiating the input field traces and resampling them to a logarithmic time scale, and (2) shifting, weighting, and summing each resampled trace to a range of depth levels also chosen on a logarithmic scale. Peak amplitudes in the resulting image matrix give a time T and depth Z from which velocity is obtained using the relation $V=2Z/T$. The locus of constant velocity is a slanted straight line in the coordinate system of the matrix.
In the usual application of migration for velocity analysis, each input trace of N samples is migrated for each of M constant velocity functions requiring $N \times M$ moveout shift calculations. In the new method presented here, a constant shift is calculated for a given resampled trace, for each depth into which it is summed. This reduces the number of calculations per trace to about N, resulting in a significant improvement in computing efficiency.
The operation of the algorithm is illustrated using synthetic and physical model data.
GEOPHYSICS, VOL. 48, NO. 11

0930 Seismic methods
APPLICATION OF SEISMIC REFLECTION DATA TO DISCRIMINATE SUBSURFACE LITHOSTRATIGRAPHY
Amita Sinvhal (Formerly Department of Earth Sciences, University of Roorkee, India; presently Medical Research Council Centre, Hills Road, Cambridge, CB2 2QH, India) Kalesh Khattri
A correlation between lithology and quantitative parameters abstracted from seismic reflection data is established. The concept and methodology developed on synthetic data has been successfully applied to discriminate between two different kinds of lithologies. A particular hydrocarbon-bearing formation in a sedimentary basin in Western India has been considered, part of which is dominantly sandy (lithological composition: sand = 53 percent, shale = 21 percent, coal = 26 percent) and another part which is dominantly shaly (sand = 37 percent, shale = 60 percent, coal = 3 percent). These two different lithologies are mathematically modeled using one-step Markov chains. Their seismic responses when scrutinized in time and frequency domain and subjected to statistical discriminant analysis give a fair idea about synthetic subsurface lithostratigraphy. Seismic reflection data from the same area were considered for a similar analysis. On subjecting the data to discriminant analysis, it was again possible to discriminate between the two lithologies. Also, seismograms from different modes of the same basin could be assigned to areas of subsurface lithology. Seven seismic discriminators of subsurface lithostratigraphy have been identified, three of which were abstracted from the autocorrelation function and four from the power spectrum of the seismogram.
This analysis is a potential tool for diagnosing subsurface lithology from seismic data and may ultimately help discriminate an oil-bearing stratigraphic trap from its barren surroundings in a sedimentary basin.
GEOPHYSICS, VOL. 48, NO. 11

Geochemistry

1410 Chemistry of the Atmosphere
HYDROCARBON AND CARBON MONOXIDE EMISSIONS FROM BIOMASS BURNING IN BRAZIL
J. P. Greenberg (National Center for Atmospheric Research, Boulder, Colorado 80307) P. R. Zimmerman, L. Heidt, and W. Pollock
Field measurements of hydrocarbon and carbon monoxide emissions from biomass burning in the cerrado (grasslands) and selva (tropical forest) regions of Brazil in 1979 and 1980 are characterized and quantified.

Meteorology

Geomagnetism and Paleomagnetism

Mineralogy, Petrology, and Crystal Chemistry

Oceanography

Particles and Fields—Interplanetary Space

Particles and Fields—Ionosphere

5535 Interactions between waves and particles
CORRELATION OF AURORAL HISS AND UPWARD ELECTRON BEAMS NEAR THE POLAR CUSP
C. S. Lin and J. L. Burch (Department of Space Sciences, Southwest Research Institute, San Antonio, TX, 78284), S. D. Shawhan and D. A. Gurnett.

Simultaneous plasma and wave data obtained by the DE-1 satellite are used to study a correlation between electrostatic auroral hiss emissions at several kHz and upward electron beams at altitudes between 2 and 4 R_E near the dayside polar cusp. Among five randomly selected DE-1 passes, intense electrostatic hiss emissions at frequencies below the electron plasma frequency are found to be associated with strong upward electron beams for every pass. The frequency-time spectrum of auroral hiss near the polar cusp is sometimes characterized by a funnel shape, suggesting that the radiation is emitted from a wave source below the spacecraft. At the center of the enhanced wave region, the electron distribution function above 80 eV is characterized by two components: a hot Maxwellian component and an upward electron beam. The beams generally have a peak energy around 50 eV, a temperature around 80 eV and a density of the order of 1 cm^{-3}. The observed distribution functions are fitted by a drifting Maxwellian function for the electron beam and an isotropic Maxwellian function for the hot component. The empirically fitted plasma parameters are then used to solve the linear dispersion equation of electrostatic waves. The instability analyses indicate that whistler waves propagating with wave normal angles near a small resonance cone can be easily excited by low energy (<100 eV) upward electron beams. The frequencies of large growth rates are found below the electron plasma frequency, in agreement with the observations. Based on the model that cusp auroral hiss emissions are whistler waves propagating near the resonance cone, ray path studies indicate that the low altitude boundary of the wave source of cusp hiss is located at about 1 R_E. (Auroral hiss, upward electron beam, polar cusp).
J. Geophys. Res., Blue, Paper 3A1549

5545 Ionospheric Disturbances
CALCULATED STORMTIME VARIATIONS IN PLASMASPHERIC THERMAL ION COMPOSITION
K. J. Miller (Laboratory for Planetary Atmospheres, NASA/Goddard Space Flight Center, Greenbelt, MD 20771), H. G. Mayr and I. Harris
Model calculations describing stormtime variations in the earth's dayside plasmasphere are used to examine variations in ion composition. The model storm is initiated by high latitude thermospheric heating which generates meridional winds that carry neutral species, momentum, and energy equatorward. The thermosphere acts on the plasmasphere through collisional transfer of momentum and through chemical reactions between neutral species and ions. Over latitudes near the region of thermospheric heating, the thermosphere-plasmasphere coupling processes cause enhancement in the density of oxygen ions while protons are being lost. Meanwhile, densities of oxygen ions and protons near the equator are increasing together, almost in phase. The largest enhancements in ion density develop at latitudes near 45° invariant for both oxygen and hydrogen. (Ion composition, ion fluxes)
J. Geophys. Res., Blue, Paper 3A1551

5563 Plasma Motion, Convection, Circulation
F-LAYER IONIZATION PATCHES IN THE POLAR CAP
E.J. Weber (Ionospheric Physics Branch, AFGL, Hanscom AFB, MA 01731), J. Buchau, J.G. Moore, J.R. Sharber, R.C. Livingston, J.D. Winningham, and B.W. Reinisch.
[illegible]
Rad. Sci., Paper 3S1539

5580 Wave Propagation (Propagation through ionospheric bubbles)
PULSE DISTORTION AFTER PROPAGATING THROUGH AN IONOSPHERIC BUBBLE
[illegible] (Department of Electrical Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, 61801), K. C. Yeh
[illegible]
Rad. Sci., Paper 3S1537

5599 General (Electron Densities)
POLAR CAP ELECTRON DENSITIES FROM DE-1 PLASMA WAVE OBSERVATIONS
Ann M. Persoon (Dept. of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242), Donald A. Gurnett, and Stanley D. Shawhan
[illegible]
J. Geophys. Res., Blue, Paper 3A1486

5589 General (Ionospheric Modification)
HF-ENHANCED PLASMA LINES IN THE LOWER IONOSPHERE
[illegible] (Space Sciences Lab., The Aerospace Corp., P. O. Box 92957, Los Angeles, CA 90009)
The ionospheric modification facility at Arecibo, Puerto Rico has been used to study Langmuir waves excited in the lower ionosphere by a high-power HF radio wave. [illegible] Observatory. These measurements complement observations made in the past at higher altitudes. Enhanced plasma line spectra observed in the lower F region peak at the so-called "decay line" and contain additional spectral structure similar to that found in the upper F region. In the E region the spectra exhibit narrow peaks located at 430 ± f_{HF}, where f_{HF} is the frequency of the modifying HF wave. While strong plasma line enhancements are commonly observed in sporadic E, only weak enhancements have been detected in the normal daytime E layer. Candidate mechanisms for the E-region enhancements include the oscillating two-stream instability and direct conversion of the HF wave into Langmuir waves. (Ionospheric modification, HF radio wave, E region, Sporadic E).
Rad. Sci., Paper 3S1451

5589 General (Plasma Structuring)
ELECTROMAGNETIC THEORY OF COLLISIONAL INTERCHANGE INSTABILITIES
A. J. Olsemsen and J. L. Sperling (JAYCOR, P.O. Box 85154, San Diego, California 92138)
Finite parallel wavelength is shown to have a significant effect on the linear growth of instabilities of the Rayleigh-Taylor or E X B gradient drift types. The flute approximation, which explicitly neglects electric fields parallel to the ambient magnetic field, is asymptotically correct for long perpendicular wavelengths, if the parallel component of the electric field is primarily inductive in character. However, when the parallel electric field is primarily electrostatic, there is a profound reduction in the growth rate for long perpendicular wavelengths. This reduction in growth rate arises because parallel electron currents short-circuit the perpendicular electric field driving the instability. Parallel electric fields are more likely to be electrostatic in lower density plasmas than in higher density plasmas. Consequently, the extrapolation of structuring from low density plasmas, such as those found in the spread-F environment, to higher density ionospheric plasmas may not be reasonable.
J. Geophys. Res., Blue, Paper 3A1474

Particles and Fields—Magnetosphere

5720 Interactions between solar wind and magnetosphere
DYNAMIC VARIATION OF THE AURORAL OVAL DURING INTENSE MAGNETIC STORMS
C.-I. Meng (Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland, 20810)
The latitudinal variations of the noon sector polar cusp region and the nightside auroral oval were examined during three intense geomagnetic storms to investigate the auroral oval dynamics. The variations were compared with the ring current intensity variation (i.e.,) and with changes of the interplanetary magnetic field B_z component to determine the dominant parameter of the large-scale polar region configuration changes during magnetic storms. Deviations of the polar cusp and the midnight auroral oval from their normal quiet time position are also compared to determine the occurrence of the large-scale reconfiguration of the polar region geometry. It is found that: (1) the large (> 10° gm lat) equatorial shift of the auroral oval occurs in coordination with the equatorward motion of the polar cusp region; (2) the polar cusp is displaced by a few degrees more than the nightside auroral oval near the peak of a magnetic storm; (3) the midnight auroral oval recovers more slowly than the polar cusp region during the storm recovery phase, and (4) the midnight oval and the noon sector polar cusp region move coherently with the southward variation of the IMF B_z, but not necessarily with the Dst intensity variations. [illegible]
J. Geophys. Res., Blue, Paper 3A1541

5758 Plasma Instabilities
CHORUS-RELATED ELECTROSTATIC BURSTS AT JUPITER AND SATURN
L. A. Reinleitner (Max-Planck-Institut für Aeronomie, Postfach 20, D-3411 Katlenburg-Lindau, Germany), W. S. Kurth, and D. A. Gurnett
[illegible]
J. Geophys. Res., Blue, Paper 3A1453

5755 Plasma Instabilities
VELOCITY SHEAR INSTABILITIES IN THE ANISOTROPIC SOLAR WIND AND THE HEATING OF IONS PERPENDICULAR TO THE MAGNETIC FIELD
S. Migliuolo (High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO 80307)
[illegible]
J. Geophys. Res., Blue, Paper 3A1421

5755 Interactions between solar wind and magnetosphere
NONLINEAR EVOLUTION OF MAGNETOPAUSE TEARING MODES
F. V. Coroniti (Physics Department, UCLA, Los Angeles, California 90024) and K. B. Quest
[illegible]
J. Geophys. Res., Blue, Paper 3A1546

5710 Short-period (less than 1 day) variations of magnetic field
A REEXAMINATION OF ATS 6 MAGNETOGRAMS DATA FOR RADIALLY POLARIZED Pc 3 MAGNETIC PULSATIONS
[illegible]
J. Geophys. Res., Blue, Paper 3A1175

5785 Whistlers
ELF EMISSIONS AND RELATIVISTIC ELECTRON PRECIPITATION
R. R. West (Geophysics Program, University of Washington, Seattle, WA 98195), R. K. Parks
[illegible]
J. Geophys. Res., Blue, Paper 3A1524

5185 Whistlers
WHISTLER INDUCED SUPPRESSION OF VLF NOISE
W. E. Gail (Space, Telecommunications and Radioscience Laboratory, Stanford University, Stanford, California, 94305), D. L. Carpenter
[illegible]
J. Geophys. Res., Blue, Paper 3A1541

5799 (General)
ALBEDO OF SOOT-CONTAMINATED SNOW
P. Chýlek (National Center for Atmospheric Research, Boulder, Colorado, 80307), V. Ramaswamy and V. Srivastava
[illegible]
J. Geophys. Res., Green, Paper 3C1477

5790 General (Ionosphere)
ON THE EQUATORIAL CONFINEMENT OF THERMAL PLASMA GENERATED IN THE VICINITY OF THE RINGS OF SATURN
W.-H. Ip (Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, Federal Republic of Germany)
[illegible]
J. Geophys. Res., Blue, Paper 3A1421

5799 General (Radiation from Electron Beams)
RADIATION FROM PULSED ELECTRON BEAMS IN SPACE PLASMAS
[illegible] (Space, Telecommunications and Radioscience Laboratory, Stanford University) and P. M. Banks
[illegible]

Physical Properties of Rocks

[illegible]

6190 General (Marine Sediments)
THE EFFECTS OF HIGH PRESSURE-HIGH TEMPERATURE ON SOME PHYSICAL PROPERTIES OF OCEAN SEDIMENTS
[illegible] and Armand J. Silva (Department of Ocean Engineering, University of Rhode Island, Kingston, RI 02881)
[illegible] provide a satisfactory solution to the conflicting data which now exist between the pore water velocities inferred from non-linear thermal profiles of ocean sediments and those fluid velocities derived from Darcy's Law and laboratory permeability data.

The effects of sizeable variations in pressure and temperature upon sediment thermal conductivity are found to closely reflect the behavior of the conductivity of the liquid phase alone under these same changes in environmental conditions. This is not surprising, due to the relatively narrow range of high porosities encountered in this study. Empirical equations are developed which allow sediment thermal conductivity to be calculated as a function of temperature and void ratio. A hydrostatic pressure correction term is also presented.
J. Geophys. Res., Red, Paper 3B1212

Planetology

6510 Atmospheres of planets
MAGNETIC FIELD ORIENTATIONS IN SATURN'S UPPER IONOSPHERE INFERRED FROM VOYAGER RADIO OCCULTATIONS
David P. Hinson (Center for Radar Astronomy, Stanford Univ., Stanford, Ca., 94305)
Dual-wavelength radio observations during the occultations of Voyagers 1 and 2 provided 3.6-cm and 13-cm data on Saturn's ionospheric irregularities at two locations. Spectra of the weak fluctuations in amplitude and phase can be interpreted using the theory for scattering from a power-law spectrum of anisotropic irregularities embedded in a thin screen. Comparisons of measured scintillation spectra with the theory produced least-squares solutions for four parameters which characterize the ionospheric irregularities: (1) the axial ratio, (2) the orientation, (3) the power-law exponent of the spatial spectrum, and (4) the magnitude of the spatial variations in electron density. Scattering was observed from irregularities of approximate size 2-40 km; these lower and upper limits result from noise limitations and the method of analysis, respectively, and do not represent either an inner or outer scale. Within this range of length scales, the three-dimensional spatial spectrum obeys an inverse power law with exponent near 3.6, and the fractional variations in electron density are about 10-20%. All observed irregularities appear to be anisotropic with axial ratios greater than 4:1. Magnetic field orientations in Saturn's ionosphere were inferred from the direction of alignment of the anisotropic irregularities. When used as a test of Saturnian magnetic field models, the occultation measurements generally confirm the accuracy of the model predictions, but also suggest that a small adjustment of model parameters might improve the field representation. (Radio occultations, ionospheric irregularities, magnetic fields).
J. Geophys. Res., Blue, Paper 3A1415

6510 Atmospheres of Planets
POSSIBLE DUST DEVILS, VORTICES ON MARS
[illegible] and R.G. Lucich (Earth Science Department, California State University, Fullerton, Fullerton, California, 92634)
This paper presents the results of a study of local vortices, and dust devils, on Mars as observed by Viking Landers 1 and 2. It is found that these vortices involve wind speeds which may raise dust from the martian surface. There is no indication that these possible dust devils contribute to the planet-wide spread of major dust storms. However, it appears that they may help in maintaining the atmospheric dust content. The data indicate that there is no preference in rotation direction, or lower to core diameters of 300 m (corresponding to a region of influence of about 1 km diameter). (Mars atmosphere, dust devils, vortices).
J. Geophys. Res., Green, Paper 3C1516

6560 Interior of Moon
AN UPPER BOUND ON THE RADIUS OF A HIGHLY ELECTRICALLY CONDUCTING LUNAR CORE
[illegible], L. L. Hood, F. Herbert, and C. P. Sonett (Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721)
Abstract. Parker's [1980] nonlinear inverse theory for the electromagnetic sounding problem is converted to a form suitable for analysis of lunar day-side transfer function data by (1) transforming the solution in plane geometry to that in spherical geometry; and (2) transforming the theoretical lunar transfer function in the dipole limit to an apparent resistivity function. The theory is applied to the revised lunar transfer function data set of Hood et al. [1982a] which extends in frequency from 10^{-5} to 10^{-3} Hz. On the assumption that an iron-rich lunar core, whether molten or solid, can be represented by a perfect conductor at the minimum sampled frequency, an upper bound of 435 km on the maximum radius of such a core is calculated. This bound is somewhat larger than values of 360-375 km previously estimated from the same data set via forward model calculations because the prior work did not consider all possible mantle conductivity functions. (Conductivity, core, induction, magnetic fields).
J. Geophys. Res., Red, Paper 3B5116

6560 Meteoritics
POSSIBLE INTERNAL ORIGINS FOR MESOSIDERITES
[illegible] (Department of Geological Sciences, Rutgers University, New Brunswick, New Jersey 08903)
Abstract. Mesosiderites are very intimately mixed stony-iron breccias, including little recrystallized and highly recrystallized varieties (I-III) and a subgroup (IV) with melted matrix. All mesosiderite breccias contained some material that was hot, as indicated by pigeonite that inverted at 1150°C. Subgroup IV contained silicate and metal liquids at temperatures of at least 1300°C and 1150°C, respectively. Cooling rates are not rigorously defined, but are approximately 1°/year in the high temperature range and 1°/m.y. below 500°C. The latter cooling requires a depth of 40 km in an asteroid with a radius of 400 km, or less if porous, low-conductivity surface material is present. Cratering with metal projectiles appears incapable of generating mesosiderites: a normal impact on a rapidly cooled, metal-poor breccias. Impacts on a crust in which metal-silicate segregation had taken place could generate stony-iron breccias, but burial under an insulating blanket would be necessary to obtain slow cooling. Disruption and reassembly of two colliding bodies and accretion of differentiated planetesimals could form stony-iron breccias at depth but, as with the previous two models, the easiest way to explain the low olivine of mesosiderites is to postulate derivation from olivine-poor chondritic material. Two internal processes, turbulent metal-crust mixing during core formation and crustal blocks sinking into the core, provide a deep location with the olivine from the breccia. However, these mechanisms do not explain how the silicate and metal liquids in subgroup IV (otherwise interpreted as impact melt-rocks) could have failed to segregate in a deep, slowly cooled environment. No single model for mesosiderite origins is wholly satisfactory.
J. Geophys. Res., Red, Paper 3B5046

6560 Meteoritics
CHEMICAL AND PHYSICAL STUDIES OF TYPE 3 CHONDRITES: 2. THERMOLUMINESCENCE OF SIXTEEN TYPE 3 ORDINARY CHONDRITES AND RELATIONSHIPS WITH OXYGEN ISOTOPES
Derek W. G. Sears (Chemistry Department, University of Arkansas, Fayetteville, Arkansas 72701), Karen S. Weeks
Thermoluminescence (TL) sensitivity values for sixteen type 3 ordinary chondrites, fourteen of them from Antarctica, have been measured. The values obtained (normalized to the TL sensitivity of the Dhajala meteorite) range from 1.6 (Allan Hills A77216) to 0.010 (Allan Hills A77216), and include two (Reckling Peak A80207 and Allan Hills A77176) that are particularly low. They fill a hiatus in the TL distribution that previously existed between St. Mary's County and Bishunpur, the latter being a meteorite with one of the lowest TL sensitivities known. The histogram of TL sensitivity values now shows a single distribution with higher values preferred; it resembles the histogram for L chondrites occupying the petrologic types 3, 4, 5, and 6. There is a tendency for the TL sensitivity of meteorites to decrease as $\delta^{18}O$ increases; equilibrated meteorites have TL sensitivities of 1-50 and $\delta^{18}O$ = 4.0 to 5.0‰, while the most primitive meteorites with TL < 0.01 have $\delta^{18}O$ = 5.7 to 6.2‰. Meteorites with intermediate TL have intermediate $\delta^{18}O$. Theoretically it is possible that the range of $\delta^{18}O$ values observed may reflect progressive loss of O in the form of CO at very low temperatures, but very restrictive physical conditions and a complex history seem to be required. (Thermoluminescence, oxygen isotopes, Type 3 ordinary chondrites, metamorphism).
J. Geophys. Res., Red, Paper 3B5021

6560 Meteoritics
A THREE-DIMENSIONAL STUDY OF METAL GRAINS IN EQUILIBRATED, ORDINARY CHONDRITES
John Willis and Joseph I. Goldstein (Dept. of Metallurgy and Materials Engineering, Lehigh University, Bethlehem, Pennsylvania, 18015).
Metal particles in Guareña (H6), Colby (L6) and St. Severin (LL6) were studied by optical microscopy and by electron microprobe analysis. Observations from successive polished sections through the metal particles show that kamacite and taenite grains, which often appear to be isolated particles, are connected directly or by intervening sulfides. Also tetrataenite rims are widest when adjacent to sulfide or kamacite. These observations indicate that transfer of Ni during cooling when kamacite-taenite phase growth takes place does not occur through the silicate phases but proceeds through metal and sulfide phases or along grain boundaries. By utilizing the central Ni content of taenite grains from successive sections, metallographic cooling rates were determined more precisely than by using one arbitrary section. Cooling rates determined in this manner for Guareña, Colby, and St. Severin are 4.1 K m.y.$^{-1}$, 4.0 K m.y.$^{-1}$, and 1.0 K m.y.$^{-1}$, respectively. (Chondrites, metal, cooling rates.)
J. Geophys. Res., Red, Paper 3B5011

6560 Meteoritics
^{26}Al-PRODUCTION RATES AND ^{53}Mn/^{26}Al PRODUCTION RATE RATIOS IN NONANTARCTIC CHONDRITES AND THEIR APPLICATION TO BOMBARDMENT HISTORIES
U. Herpers and P. Englert (Institut für Kernchemie, Universität zu Köln, D 5000 Köln-1, West Germany)
The long-lived spallogenic radionuclides ^{26}Al and ^{53}Mn were systematically studied in a large number of nonantarctic meteorites by nondestructive γγ-coincidence technique and neutron activation, respectively. From the ^{26}Al-activities normalized to the main target element, silicon, an average production rate of 299 ± 55 [dpm/kg Si_{equ}] was derived. Based on 15 chondrites with exposure ages ≥ 12 x 10^6a and depth profiles of Bruderheim and Keyes, an average production rate ratio [^{53}Mn/^{26}Al]$_{prod}$ = 1.40 ± 0.15 [dpm/kg Fe / dpm/kg Si_{equ}] was calculated, which seems to be depth-independent for meteorites with preatmospheric radii ≤ 15 cm. ^{53}Mn/^{26}Al radiation ages for 29 stones with short exposure ages were determined. A comparison of our results with the respective ^{53}Mn- and ^{21}Ne-exposure ages generally shows a good agreement. The cosmic ray bombardment age scale covered by this method is 1 x 10^6 < T_{rad} < 10 x 10^6a. (Chondrites, cosmogenic radionuclides, production rates, production rate ratios, exposure ages).
J. Geophys. Res., Red, Paper 3B5001

6560 Meteoritics (Enstatite Chondrites)
IMPACT MELT-ROCK CLASTS IN THE HVITTIS ENSTATITE CHONDRITE BRECCIA: IMPLICATIONS FOR A GENETIC RELATIONSHIP BETWEEN EL CHONDRITES AND AUBRITES
A. E. Rubin (Department of Mineral Sciences, Smithsonian Institution, Washington, D.C. 20560)
The Hvittis enstatite chondrite breccia contains 5% volume dark clasts which appear to be impact melt-rocks. The largest clast (Clast A) is 2.5 cm in diameter; it has an igneous texture, no chondrules, and is depleted in metallic Fe,Ni and sulfide. Its fine grain size, low-Ni kamacite and schreibersite, and rare martensite resulted from rapid cooling. The abundance of melt-rock clasts in Hvittis suggests that the breccia resided at its parent body surface. However, the apparent absence of EL chondrites with solar wind-implanted rare gases suggests that the EL parent body was too small to develop a substantial regolith. The bulk composition of Clast A is very similar to that of average aubrites, except for a seven-fold enrichment of S, Cr, and Mn. These elements are concentrated in the sulfides. It thus is possible that the clast was derived from one of the sulfide-rich regions of the Hvittis matrix. If so, then aubrites may be genetically related to EL chondrites. (Breccia, aubrites, impact melt-rocks).
J. Geophys. Res., Red, Paper 3R5008

6560 Meteoritics
EXPERIMENTAL STUDY OF SEGREGATION IN PLANE FRONT SOLIDIFICATION AND ITS RELEVANCE TO IRON METEORITE SOLIDIFICATION
R. Sellamuthu and J. I. Goldstein (Dept. of Metallurgy and Materials Engineering, Whitaker Lab #5, Lehigh University, Bethlehem, PA 18015).
A directional solidification technique was developed and applied to the problem of fractional crystallization of an iron meteorite parent body. Samples of Fe-Ni alloys close to meteorite compositions, and containing S, P, and C were made. The solidified structures contain secondary phases such as sulphides within the proeutectic single crystal austenite (taenite). As a result of these experiments, we propose that the secondary phases observed in iron meteorites were formed during primary solidification of austenite (taenite). The measured composition profiles of Ni, P and C in the alloys were used to explain the elemental distribution within a chemical group of iron meteorites. An analytical procedure was applied to determine the equilibrium distribution coefficients as a function of fraction solidified for Ni and P from the composition profiles. The distribution coefficients of Ni and P agree with previous values. These distribution coefficients are of particular interest in the determination of the elemental distributions in iron meteorites. (Distribution coefficients, iron meteorite, directional solidification.)
J. Geophys. Res., Red, Paper 3B5010

6599 General
PIECES OF THE ANCIENT LUNAR CRUST: AGES AND COMPOSITION OF CLASTS IN CONSORTIUM BRECCIA 67915
K. Marti (Chemistry Department B-017, University of California, San Diego, La Jolla, California, 92093), U. Aeschlimann, P. Eberhardt, J. Geiss, N. Grögler, D. L. Jost, J. C. Laul, H.-S. Ma, R. A. Schmitt and G. J. Taylor
We discuss the composition and chronology of clasts representing three minor lithologies in consortium breccia 67915. The lithologies studied are: sodic ferrogabbro, pristine troctolitic anorthosite (67915,28), and granulitic troctolitic anorthosite (67915,67). These lithologies were presumed to represent samples of the ancient lunar crust. The pristine troctolitic anorthosite, a typical member of the pristine anorthosite suite, contains little or no trapped liquid component with its two-phase mineralogy. The plagioclase separates have ^{39}Ar-^{40}Ar plateau ages of 4.10 ± 0.06 b.y., and a final rise in the age pattern may represent a 'memory' of the earlier evolution. The granulitic troctolitic anorthosite, which has 11 times larger REE abundances, displays a continuous rise of the ^{40}Ar/^{39}Ar ratio. The last 25% of the ^{39}Ar release data establish a minimum age of > 3.9 b.y., but the ^{244}Pu/Nd chronology suggests an age of ~4.3 b.y. The sodic ferrogabbro samples, which appear to be members of the Mg-gabbronorite group of pristine rocks, show large Ar losses but indicate plateaus in the low-temperature data, suggesting a metamorphic event more recently than 260 m.y. ago, a time that is consistent with the North Ray impact event 50 m.y. ago.
J. Geophys. Res., Red, Paper 3B5054

Seismology

6950 Seismic Sources
CONSTRAINTS ON PLATE MOTIONS IN SOUTHERN PAKISTAN AND THE NORTHERN ARABIAN SEA FROM THE FOCAL MECHANISMS OF SMALL EARTHQUAKES
R.C. Quittmeyer (Woodward-Clyde Consultants, Wayne, NJ 07470), A.L. Kafka
The focal mechanism and depth were determined for nine small earthquakes (M_0 < 10^{25} dyne-cm, M < 5.5) that occurred in southern Pakistan and the northern Arabian Sea from an analysis of the vertical component of Rayleigh waves in combination with limited first-motion data. Focal parameters were determined from the Rayleigh waves by using an event-pair method of analysis. For earthquakes that are located very close to each other (< 50 km), the event-pair method is able to remove a significant proportion of propagation effects at all periods in the range of interest (20-50 sec). For events separated by more than ~100 km the propagation effects are reduced for only the longer periods (~40-50 sec). The earthquakes that were studied provide evidence for a model of plate interactions in the vicinity of the southern Pakistan triple junction. The Owen fracture zone is a transform fault that accommodates right-lateral motion between the Indian and Arabian plates. The plate boundary in the vicinity of the Murray ridge is also partially made up of transform segments that strike subparallel to the Owen fracture zone. Spreading centers may also exist in the vicinity of the Murray ridge, but were not documented by seismic or other evidence. The slip azimuths for earthquakes along this boundary are significantly more northerly than those predicted by various regional and world-wide models of plate motion. The Arabian plate is being subducted beneath the Eurasian plate along the southern coast of Pakistan. Slip vectors for earthquakes along this boundary trend north-northeasterly in general agreement with predicted directions. Left-lateral motion is documented along the boundary between the Indian and Eurasian plates in southern Pakistan. The predicted direction of relative motion between these plates is not significantly different from that observed. Two of the earthquakes studied appear to be intraplate in nature. The depth and focal mechanism of one intraplate event, which may have occurred within the accretionary prism along the Makran coast, however, is based on limited data. The other intraplate earthquake occurred within sedimentary deposits along the western edge of the Indian subcontinent near the Indian-Eurasian plate boundary. (Surface waves, Pakistan, tectonics)
J. Geophys. Res., [illegible], Paper 3B1511

6950 Seismic Sources
LINEAR MOMENT TENSOR INVERSION FOR SHALLOW THRUST EARTHQUAKES COMBINING FIRST-MOTION AND SURFACE WAVE DATA
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We derive a linear moment tensor inversion method (which we call nodal plane inversion) for obtaining a double couple focal mechanism when one nodal plane is known. This typically is the case for shallow thrust events, for which only the steeply dipping nodal plane can be determined from teleseismic first motions. Conventional moment tensor inversion methods are known to fail for these events because the portion of the moment tensor corresponding to vertical dip-slip faulting is extremely inefficient in exciting surface waves. In this paper we invert long period (256 sec) fundamental mode Rayleigh waves from the IDA network; the inversion technique can also be applied to body wave amplitude data or to entire records (as a sum of normal modes), given the appropriate normal equations.
We study several shallow (h < 35 km) thrust earthquakes for which the steeply dipping nodal plane can easily be found from body wave first motions. In contrast to standard surface wave moment tensor inversion techniques, which have serious stability problems for such shallow events, our technique successfully finds the scalar moment and second nodal plane. (Seismic sources, surface waves, instruments and techniques).
J. Geophys. Res., Red, Paper 3B1510

Social Sciences

1310 Economics
ESTIMATING DEMAND FOR INTAKE WATER BY SELF-SUPPLIED FIRMS
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The proper specification of price variable in estimating the demand for intake water by self-supplied firms is a neglected subject in the literature. Previous studies have used measures of average cost, but neoclassical economic theory suggests firms respond to marginal costs. Using data from a sample of paper and chemical firms in Arkansas the null hypothesis that there is no significant difference in the estimates of industrial water demand using either average or marginal costs is tested. It is shown that the use of average cost provides a better estimate of water use in terms of statistical fit and predictive capabilities. (Industrial water demand).
Water Resour. Res., Paper 3W1615

Solar Physics, Astrophysics, and Astronomy

7720 Electromagnetic Radiation
ESTIMATING THE VARIABILITY OF THE SOLAR FLUX BETWEEN 200 AND 300 NM
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Observations of the solar ultraviolet irradiance during 1979 (solar maximum) by the Solar Backscatter Ultraviolet experiment on the Nimbus 7 satellite have established that the irradiance at wavelengths between 200 and 300 nm is modulated by solar rotation. This short term variability, which is of the order of 3% at 200 nm and 1% at 250 nm, is associated with the evolution and rotation on the solar disc of plage areas which are enhanced in ultraviolet emission. By using ground based Ca II K observations of the fraction of the disc covered by plage during 1979, the intensity ratios for plage to quiet sun emission at these wavelengths have been derived. During the 11 year solar cycle the number of plage regions on the solar disc fluctuates. As well, there is an accumulation of active network arising from the remnants of decayed magnetic features. A three component model of the solar irradiance is used to estimate the temporal behaviour of the ultraviolet emission between 200 and 300 nm, resulting from changes throughout the solar cycle in the active features on the disc. These calculations suggest that for solar cycle 21 the flux variability at 200 nm is 25%, decreasing to 10% at wavelengths between 210 and 250 nm, and to 2% at 300 nm. Ultraviolet flux variability of this magnitude corresponds to an average increase in the total solar irradiance from 1976 to 1979 of about 0.05%. For comparison, the average reduction in the total solar irradiance from 1976 to 1979 due to sunspot blocking is 0.01%. Because of the enhanced ultraviolet emission from solar active features, the variability of the total solar irradiance during cycle 21 is predicted to be less than is calculated by models which consider only the effects of sunspot blocking. This result is consistent with the need for an added faculae brightening term in total solar irradiance models.
J. Geophys. Res., Blue, Paper 3A1571

Volcanology

8499 Volcanology topics
ERUPTION FORECASTING AT KILAUEA VOLCANO, HAWAII
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Data from a network of seismometers, a tiltmeter and the pattern of summit inflation between eruptions have made qualitative eruption forecasting possible on Kilauea volcano for over 20 years. This paper formulates quantitative forecasting by calculating the probability of an eruption based on current levels of tilt, tilt rate, seismicity, and fortnightly tide. Rates of eruption probability as a function of various parameters are derived using a set of 29 eruptions during 1959-79. The method tests the precursory significance of various parameters over different time scales and determines probabilities by comparing data before eruptions with data values generally. Tilt level is an eruption precursor significant to better than 99.9% when averaged over any interval from 1 to 20 days. Tilt rate is a precursor significant to better than 99.98%, but noise in the data requires that it be averaged over 10 days or more. Earthquakes are a short-term precursor significant to better than 98% when averaged over 1 to 10 days for larger earthquakes near the summit caldera, and over 5 to 20 days for very small earthquakes within the caldera. The fortnightly modulation of tides influences eruption probability and has a precursory significance of 97%. Probabilities are independent of the time elapsed since the last eruption. The eruption probability, when tested against the eruption record from which it was derived, is significant to the 99.88% level when compared with random guessing. Ongoing 1-day, 7-day, and 30-day forecasts are calculated by computer at the Hawaiian Volcano Observatory and supplement the qualitative interpretation of geophysical data.
J. Geophys. Res., Red, Paper 3B1551

General or Miscellaneous

9840 Techniques applicable in more fields
MAXIMUM ENTROPY SPECTRAL ANALYSIS OF ARTIFICIAL SINUSOIDAL SIGNALS
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We applied the Burg's algorithm to the spectral analysis of a signal which is the sum of 11 sinusoids as intermixed with different noise levels. We paid particular attention to those features which for single sinusoids represent the crucial point of this technique and found that, for a multicomponent signal, the frequency shiftings are smaller than for single sinusoids and the splitting phenomena tend to occur at much higher orders of the prediction error filter. For a noise power smaller than 17% of the power of the lowest amplitude component, all the expected peaks were easily identified and most of the power was concentrated in very narrow ranges of frequency. The behavior of the final prediction error might provide useful suggestions only for higher noise levels and the choice of the limits for the application of the Akaike's criterion is ambiguous and strongly dependent on the noise level. An analysis of individual signal components does not confirm the results of previous investigations in that the splitting hierarchy appears independent on the wave parameters. We also examined the effects of the progressive addition of new components and found that it progressively leads to smaller frequency shifts and higher orders of appearance of splitting phenomena. (Maximum entropy, spectral analysis).
J. Geophys. Res., Blue, Paper 3A1215